4-2013

# Oil Dependence Reduction Assessment, 2013

Maine Governor's Energy Office

La Capra Associates, Inc.

# OIL DEPENDENCE REDUCTION ASSESSMENT

Technical Report

*PREPARED FOR*

**Maine Governor's Energy Office**

*PREPARED BY*

**La Capra Associates, Inc.**
One Washington Mall, 9th Floor
Boston, MA 02108

70 Center Street, Suite 304
Portland, ME 04101

April 2013

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

In 2011, "An Act to Improve Maine's Energy Security" ("the Act"), Chapter 400, LD 553 became law. The Act had two primary goals: (1) to lower the cost of energy in the state, hence implying that economic affordability is paramount, and (2) to document any progress in meeting oil dependence targets. The Act required the Maine Governor's Energy Office ("MGEO") to develop a plan to reduce oil usage across all sectors of the Maine economy. This study provides input to that plan and is required by the Act to be developed "in consultation with stakeholders and Efficiency Maine." Most importantly, the Act sets reduction targets for total oil usage:

- 30% below 2007 levels by 2030 and
- 50% below 2007 levels by 2050.

Based on our analysis and research, Maine is expected to achieve the 30% target reduction from 2007 levels by 2030 under baseline conditions, which are intended to include existing policies (mostly at the federal level) and forecasted market conditions. Clearly, additional assumptions regarding individual household and business behavior are embedded in such a conclusion, and supportive strategies and policies at the state level will speed the attainment of reduction targets and assure that targets are met. Our analysis also shows that additional strategies and policies (especially targeted toward transportation) will need to be pursued to achieve the 50% reduction by 2050.

Determination of a set of policies and strategies to achieve a distant goal is difficult, since little is known of future markets, fuel prices, and technological developments, all of which will impact the attractiveness of current technologies relative to changes in these technologies and the creation of additional technologies. Nevertheless, this study includes findings based on a review and analysis of available studies, discussion with various stakeholders, and independent analyses of the cost and resource potential of different strategies.

In general, policies and strategies can influence oil dependence in two ways: (1) by improving the efficiency of current oil usage in terms of reducing the number of gallons needed to provide the same level of comfort or service and (2) conversion to an alternative fuel that can provide the same level of comfort or service at a lower cost.

Based on our review of available strategies and experience to date with these strategies, use of thermal efficiency in buildings should be prioritized over the near term. In particular, data show that weatherization of the existing housing stock is the most cost-effective strategy that can yield immediate oil reduction benefits. Additional viable energy efficiency strategies include replacement of inefficient equipment and provision of low-interest financing. Unfortunately, determining funding sources to improve the efficiency of oil usage has been a challenge not just in Maine but other New England states. Oil distribution and sales are not regulated, and existing system benefit funds derived from electricity and natural gas utility customers have restrictions on their usage. Any oil reduction plan should consider ways to expand efforts to lower the use of expensive oil, including use of funds collected from electricity and natural gas

companies, surcharges on oil purchases, and leveraging of federal or other funds (such as greenhouse gas reduction funding or state funding support through use of general funds.) The list of strategies should also include outreach and education of consumers on options they individually can pursue in addition to availing themselves of state-sponsored energy efficiency programs.

Use of renewable fuels to meeting heating needs is an option, but cost-effective solutions are limited to use of biomass (wood or wood pellet). Biodiesel is an option but one that does not have the potential to offer significant savings to users. Of course, use of electricity is a cost-effective solution in some cases (and features renewable resources in the overall generation mix), but this is a second best option.

On the other hand, an analysis of current and anticipated market conditions shows a definitive price advantage to use of natural gas as an alternative fuel. Consequently, policies should promote expansion of pipeline-delivered gas through local distribution companies. Off-pipeline strategies (and propane use in some cases) are also viable due to the price differentials with distillate but are limited in their coverage of all sectors due to minimum scale requirements. Nevertheless, these strategies should be promoted as a transition to greater investment in natural gas delivery infrastructure. Additional work is necessary to examine the costs and potential for additional expansion plans in different parts of the state.

In terms of where strategies should be focused over the longer term, oil reduction in the transportation sector continues to provide the most challenges. Market forces have caused industrial customers in particular to seek cheaper options to petroleum usage, thus significant progress has been made in that sector. Commercial users also have the same market incentive but adoption of strategies has been slower, possibly due to lower scale economies than industrial customers. Residential customers have converted to alternative fuels (notably biomass or wood) and have been provided incentives through energy efficiency programs that have leveraged conversion decisions to also promote efficiency improvements.

In the transportation sector, savings are available but barriers exist—fueling infrastructure needs to be expanded and alternative fuel vehicles feature an upfront cost premium. Public transit and other strategies that reduce vehicle miles traveled or improve overall transportation fuel usage continue to be important but are unlikely to provide the necessary scale of reductions to meet the 2050 targets. Expansion of alternative fuel usage by municipal and other fleet vehicles is also important, but long term strategies should focus on fuel conversion of long-haul trucking, which shows the highest rates of petroleum usage among transportation modes. Federal fuel efficiency standards for light duty vehicles are forecasted to have a significant impact on reducing petroleum usage in passenger cars, but this decrease will be mitigated somewhat by the increase in fuel usage by long-haul trucking. As a result, development of alternative fuel infrastructure—fueling stations and possibly, pipelines to provide fuel to these stations—appears to be a prerequisite to meeting the 2050 goals.

# 1. INTRODUCTION

The State of Maine, similar to the other New England states, remains reliant on oil across a variety of sectors. Besides being the critical fuel for the transportation sector (common across the United States), Maine features the highest percentage of households that heat with oil; approximately 70% of Maine households using oil as their primary heating fuel.[1] Though this percentage has declined over time and many industrial customers in the state have converted to other fuels, use of heating oil in inefficient systems provides unaffordable energy to consumers in the state relative to users of natural gas, for example, who have enjoyed reductions in the price of the underlying commodity due to the continued development of shale gas resources throughout the United States[2]. Overall, continued use of oil creates a number of concerns for some policymakers, including environmental impacts, reliance on foreign sources, and, most importantly from the perspective of this study, the negative impact on economic development within the state.

Indeed, this reliance on oil has been a concern for quite some time[3], but extra focus on oil reduction was motivated by the high prices that occurred approximately 5-6 years ago. In November 2007, a Governor's Executive order established a task force to examine immediate steps that could be taken to address reduce the negative economic impacts of high oil prices on consumers and businesses.[4] Oil dependence was subsequently discussed in the January 2009 Comprehensive Energy Plan. More recently, the Legislature passed "An Act to Improve Maine's Energy Security" ("the Act"), Chapter 400, LD 553. The Act had two primary goals: (1) to lower the cost of energy in the state, hence implying that economic affordability is paramount, and (2) to document any progress in meeting oil dependence targets.

The fundamental goal of this study is to provide the Maine Governor's Energy Office ("MGEO") with assistance in developing policy, legislative, and administrative recommendations on oil use reductions. With this study, we hope to inform the MGEO regarding different oil reduction strategies through examination of publicly available data and studies, discussion with stakeholders, and analysis of the costs of different options (including a brief description of important barriers that need to be overcome). As such, the objective of this report is to provide

[1] U.S. Census (2011).

[2] An interesting byproduct of the additional gas production enabled by horizontal drilling and hydraulic fracturing (or "fracking") across the United States has been increasing oil production as well. Though this could potentially diminish concerns regarding dependence on foreign oil, these additional discoveries have not had a significant impact on the market price of oil, which is set on a worldwide basis (unlike natural gas). On the other hand, there have been price reductions in propane (also known as liquid petroleum gas or "LPG"), which can be used where pipeline gas options are not viable due to long distances between customers or low population densities.

[3] A 2003 Study that examined opportunities for improving Maine's energy policies discussed the state's high reliance on oil, but emphasized oil reduction in terms of efficiency of overall usage, rather than conversion to cheaper sources. At the time, oil was quite competitive with alternative fuels.

[4] The results of this effort were documented in a 2008 report (discussed below).

technical background and input rather than make specific recommendations for further administrative or legislative action.

## 1.1 LEGISLATIVE AND POLICY CONTEXT

The legislature approved the Act in June 2011, and the bill became law shortly thereafter. The Act requires the MGEO to develop a plan to reduce oil usage across all sectors of the Maine economy. These sectors are not explicitly defined, thus we provide one definition in later sections of the report. This study is to be developed "in consultation with stakeholders and Efficiency Maine."

Most importantly, the Act sets reduction targets for total oil usage:

- 30% below 2007 levels by 2030 and
- 50% below 2007 levels by 2050.

The Act is silent on whether these reductions should be applied equally across all sectors or in total. The Act is also silent concerning the rate at which these reductions should be achieved but it does refer to a "reasonable trajectory" to meeting these targets. We provide some analysis of both these issues in a later chapter.

In terms of strategies, the plan is to focus on near-term policies and infrastructure changes and prioritize energy efficiency and alternative energy. The Act does not define "alternative energy," but it is important to distinguish between alternative energy as non-fossil or renewable energy and alternative fuels to oil, which usually include natural gas—for example, analysis of alternative fuels in transportation include electricity, compressed natural gas ("CNG"), liquefied natural gas ("LNG"), and hydrogen. Finally, the study is to draw upon existing analyses, data and studies (specifically mentioning the 2009 Comprehensive Energy Plan and Efficiency Maine Trust's triennial plan cost), and include cost and resource estimates "for technology development needed to meet the oil dependence reduction targets." Though we provide some primary analyses, especially in the critical area of determining costs of conversion to natural gas, we rely on existing work.

## 1.2 STUDY METHODOLOGY AND REPORT OUTLINE

We first provide a brief review of existing studies specifically related to reducing oil usage in Maine. The literature on reduction in oil dependence is extensive, especially on a national level, thus the focus is on Maine-specific studies, since oil usage and dependence (outside of transportation usage) varies significantly across the United States. We also include a review of the specific studies mentioned in the Act for relevance to the goals of this study. Following this literature review, we examine the progress since 2007—the base year for the target calculation—in meeting the oil reduction targets. We conclude the second chapter with a calculation of baseline consumptions in order to establish the necessary target reductions and provide a sense of scale when investigating the extent of strategies that need to be pursued.

This calculation is important since it shows that reductions from more than one sector are necessary to meet the Act's targets on a statewide basis. We also provide some observations on what can be considered as baseline conditions (and thus not require additional state action).

In the third chapter, we describe some of the options and strategies that could be employed to reduce oil dependence. These options and strategies are employed by private actors—for example, homeowners and businesses—but government can play a role in providing incentives for certain actions. Following this discussion, we describe (in Chapter 4) the stakeholder process—how we obtained stakeholder participation and input and a short description of the various perspectives, comments, and recommendations provided by stakeholders.

In the final chapter, we examine the costs of different strategies and approaches to reducing oil dependence. The cost estimates are necessarily high level and approximate, since actual costs will depend on many variables—extent and timing of strategies, existing market conditions, customer characteristics, etc.—but they provide interesting insights into the differences in costs among fuels, strategies, and sectors.

# 2. LITERATURE REVIEW AND BASELINE

A literature search was conducted of relevant studies and reports, both on a national and state level, related to oil reduction strategies and potential policy recommendations. The literature on reducing oil dependence (on a national scale) is vast, but we focused on studies most related to the characteristics of Maine's oil consumption and trends and that included discussion and analysis of strategies that could be employed to reduce oil consumption specifically in Maine.

As part of this literature review and background, we developed a baseline level of oil consumption of oil for Maine using a combination of the Department of Energy (DOE), Energy Information Administration's (EIA's) 2013 Annual Energy Outlook (AEO) Reference case and EIA's State Energy Data System (SEDS) database for Maine. This baseline is used to provide a forecast to determine target levels of reductions in order to meet 2030 and 2050 goals, as required by the Act, and to analyze consumption progress to date. We calculate this baseline by different energy sectors in order to inform the discussion of different strategies found in a later chapter.

## 2.1 PRIOR STUDIES

As mentioned in the prior chapter, oil dependence in Maine is not a new concern, but there have been relatively few studies focused on specific topic of oil reduction strategies and costs until the past couple of years. Market forces (particularly the sustained outlook for low natural gas prices) have provided economic justification for businesses and households to seek alternative fuel sources. Given the age of the housing and building stock in New England, oil usage for space and water heating is much more common than other parts of the country. Until relatively recently, the dependence on oil was not a concern due to the relatively stable relationship between oil and natural gas prices—both fuels are considered substitutes, thus prices were highly correlated. Indeed, a 6:1 ratio was established as a rule of thumb to reflect the thermal equivalence (heating value in british thermal units, or btus) between a barrel of oil and a Mcf (thousand cubic feet) of natural gas, and applied to gauge divergence in the correlation between the two fuel prices. In 2012, this ratio exploded to a 70:1 ratio and is expected to stay high.[5] The literature review provided below reflects this increasing concern starting with a 2008 report.

**Governor's Pre-Emergency Energy Task Force Final Report (2008)**

This report documented the efforts of a task force that was formed following a strong run-up in oil prices in 2007-2008, highlighting seven recommendations. These recommendations were characterized as "short-term" actions and drew upon the existing energy and transportation

[5] EIA, "Today in Energy", April 13, 2012.

programs in the state at the time. The actions included greater education (including notifying customers of available alternatives), use of audits and expansion of weatherization[6], and investigation of alternative transportation options (including transit). Though the emphasis of this report was use of existing strategies and funding sources, many of these strategies have since been implemented in a more extended fashion (especially since federal funds were made available).

**State of Maine Comprehensive Energy Plan 2008-2009, Governor's Office of Energy Independence and Security, January 2009**

This document details a comprehensive energy plan using a 50-year planning horizon for the state of Maine, as mandated by legislation, that looks at reliable, sustainable, and clean energy supplies that are economically beneficial and environmentally responsible to Maine's energy consumers. The plan states that in 2007, Maine residences and businesses were nearly 80% dependent on oil and effectively 100% reliant on petroleum products to fuel the rail, truck, bus, and automobile transportation fleets. In addition, when a barrel of oil reached $147 in July 2008, it was estimated that the State of Maine would spend and export over $6.5 billion out of the state for oil use. In light of the spike in oil prices at the time the plan was written, the plan included a long-term focus on Maine becoming energy independent. The plan identifies six general strategies with accompanying goals, objectives and implementation measures.

The plan strongly promotes strengthening energy efficiency, conservation and weatherization with goals that include weatherizing 100% of Maine residences and 50% of Maine businesses within 20 years. While the plan recognizes that achieving all cost-effective energy efficiency is a number one priority, investigating the future use of renewable and indigenous energy sources is also mentioned as a strategy.

The plan also recommends improving transportation and fuel efficiencies by a combination of land-use planning, promoting low-carbon fuel standards and fuel efficient vehicles, and supporting state transportation investments. Finally, the plan encourages promoting natural gas as a transitional fuel and expanding the natural gas infrastructure to all sectors in Maine.

[6] Specifically regarding weatherization, the report found "Maine's housing stock is old, inefficient and predominantly relies on heating oil for space heating, and if Maine households burned 10% fewer fossil fuels per year, it would put $350 million into the Maine economy and would create 3,700 new jobs." The report recommended that Maine "Implement an aggressive statewide energy efficiency program for the residential sector with a priority on reducing home heating oil use that would ensure that energy efficiency and weatherization programs are available to all Maine consumers whether they use home heating oil or propane or kerosene or natural gas." (Governor's Pre-Emergency Task Force Final Report, 2008) p.15.

**Summary Report of Recently Completed Potential Studies and Extrapolation of Achievable Potential for Maine (2010-2019), Summit Blue & ACEEE, December, 2009[7]**

This study was commissioned by the PUC in order to estimate the amount of potential energy savings that could be cost-effectively achieved for heating oil and propane, as well as required funding levels necessary to achieve goals. The study extrapolates the findings and cost estimates from other potential studies and applies the extrapolations to Maine forecasted sales and revenue. The focus of the study is on "achievable potential", which is defined as all efficiency measures that are technically feasible, cost effective, and can overcome adoption and market barriers. The study presented "median" results, which simply takes the median results from all the studies and "best fit high" results, which account for a number of factors including geography, retail price, saturation of electric space and water heating, role of fuel switching, and sales by sector in order to improve application to Maine. Table 1 shows the achievable potential savings as a % of sales and first year costs, for fuel oil and propane, respectively, and the total spending amount required over ten years to enable all cost-effective and achievable potential.

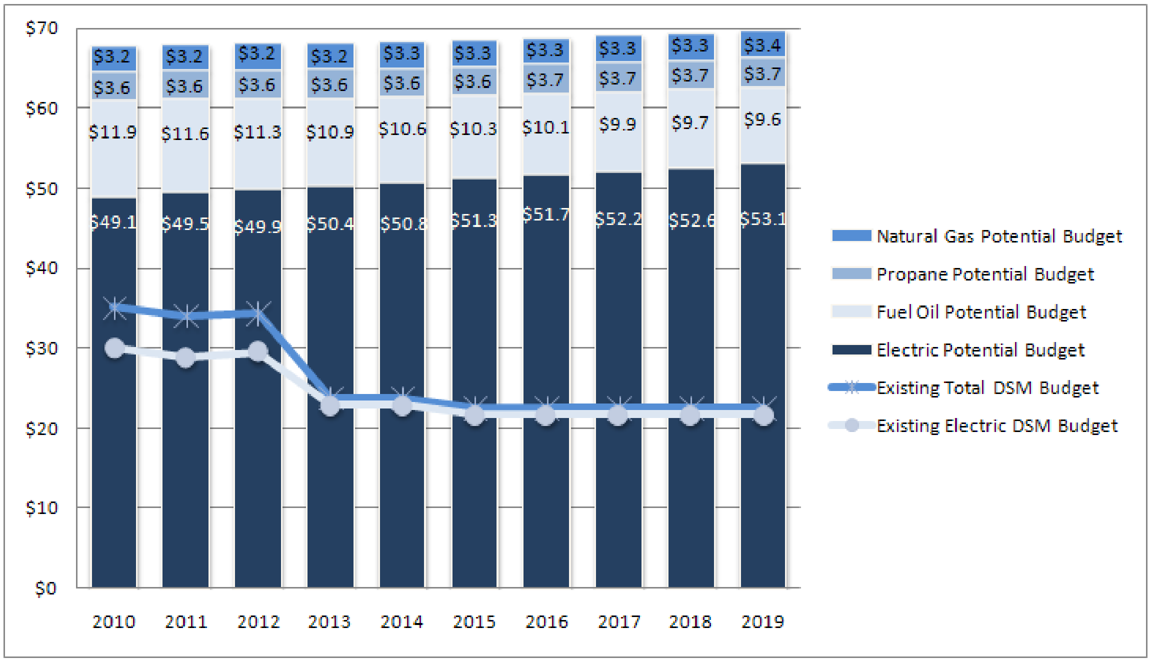
**TABLE 1:** MAINE ACHIEVABLE POTENTIAL SAVINGS AS % OF SALES AND FIRST YEAR COST

| Fuel | Result | Annual Savings as % of Sales | First Year Cost/ MMBtu | Total Cost ($ Millions) |
|---|---|---|---|---|
| **Fuel Oil** | Best Fit-High | 1.4% | $29.0 | |
| **Propane** | Best Fit-High | 0.8% | $45.4 | |
| **Fuel Oil/ Propane** | Ten-Year Results | | | $143 |

Figure 1 below compares the fuel oil, propane, natural gas and electricity budgets to existing demand-side management (DSM) budgets. This graph demonstrates that substantially more funding would be necessary to achieve the potential savings listed in Table 1 (and for other fuels and energy resources).

7 http://www.efficiencymaine.com/docs/board_meeting_documents/Maine%20Potential%20Study%20Results%20%2012%2020%2009.pdf

**FIGURE 1:** MAINE 2010 -2019 BUDGET REQUIRED TO ACHIEVE BEST FIT HIGH POTENTIAL VS. EXISTING DSM BUDGET




**Final Report: Heating Fuels Efficiency and Weatherization Fund, of the Efficiency Maine Trust, December 15, 2010**

In December, 2010, the Efficiency Maine Trust submitted a report to the Legislature analyzing potential energy efficiency initiatives that could help Mainers lower their heating costs.

The report:

> "describes how the Trust's programs would evolve to benefit more than 25,000 homes and businesses annually, introducing a new suite of low-cost, basic improvement options that are accessible for all Maine consumers. On a parallel track, it contemplates maintaining a program to achieve deep savings of 25% or more, using energy audits, developing a priority list of improvements, and providing modest rebates towards the cost of energy upgrades. Finally, it reviews the funding options available and briefly discusses the advantages and disadvantages of each." (pg. 1)

The Trust estimated that the benefits to the typical household participating in even the lowest-cost initiatives would be to lower their annual heating costs by $125-$250 per year due to reduced energy waste. It was also projected that households participating in the deep retrofits program would achieve savings of 25%-50% of their energy consumption. This report reviewed multiple funding options, and concluded that the establishment of a systems benefit charge on heating fuels would offer a more reliable and sustainable mechanism than all the other options

reviewed. The projected cost impact on the average Maine homeowner would be $2 per month on their heating bill.

**Report of the Advisory Committee on Reducing Air Emissions Sources' Reliance on Fuel Oil, Maine Department of Environmental Protection, January 2012**

This report found that substantial reductions in fuel oil consumption (almost all in residual oil) have already occurred and will continue to occur in the near term due to the relatively low natural gas prices that are incentivizing facilities to convert to natural gas and pursue energy efficiency projects.[8] The completion of the natural gas pipeline extension in Maine in the late 1990s, combined with the recent drop in natural gas prices, has resulted in a decline in residual fuel oil use as more facilities, such as paper mills, convert to natural gas. The study highlights barriers to oil reduction and cites specific facilities in Maine that have switched fuel sources. Some key points include:

- There is potential for combined heat and power biomass (harvested in Maine) to displace more costly non-domestic and dirtier fuels.
- Maine has many large industrial multi-fuel boilers, which have the potential to be replaced with biomass.
- With help from a $1 million grant from Efficiency Maine Trust, the Jackson Laboratory in Bar Harbor installed a large pellet-fired boiler that is expected to reduce oil consumption by over 1.2 million gallons per year.
- Woodland Pulp and Bath Iron Works replaced over 11.5 million gallons of annual residual oil consumption with natural gas.
- Waste materials also have a growing role in energy supply in Maine.
- Using alternative energy sources such as geothermal, electric thermal and solar thermal has potential to expand further in Maine in commercial, institutional, and small-industrial facilities. For example, geothermal systems have been installed in several businesses including Hannaford's supermarkets, University of Southern Maine, and Portland International Airport.

**Triennial Plan of the Efficiency Maine Trust, 2011-2013**

This document represents the Trust's first 3-year plan, as required by the enabling legislation. The overarching goal of the Trust (and the plan) was to help consumers achieve energy savings. The plan covered all fuels[9] (but not all sectors) and provided a description of recommended

[8] These reductions (mostly in the industrial and electric generating sector) have also led to reductions in greenhouse gas emissions. Since 2003, emissions from petroleum combustion in all sectors have declined by 3.84 $MMTCO_2$. "Fourth Biennial Report on Progress Towards Greenhouse Gas Reduction Goals." January 2012.

[9] Efficiency programs in Maine were expanded to examine efficiency across all fuels effective July 1, 2010. Thus, the 2011-2013 Plan represents the first planning document related to this expanded mission.

strategies (including providing a contextual discussion of principles and objectives). Therefore, though the plan mentions that 85% of Maine's energy usage is supplied from outside of the state, the focus of the plan was not necessarily on reducing oil consumption, but rather on reducing usage of all fuels to enable cost savings. Nevertheless, oil reduction is one of the three statutorily established goals—reduction in oil usage by 20% (compared to 2007 levels) by 2020—and is supported by another of the three goals—weatherization of 100% percent of homes and 50% of businesses by 2030.

In terms of strategies, the plan contemplated expanded use of cost-effective energy efficiency, which it claims is the least-cost resource and cheaper than heating oil. Strategies are split into residential and business strategies and savings are estimated by strategy and by "fuel." In terms of relevance to this study, the 3-year plan originally projected that it would save 68,000 barrels of oil in its first year, 169,000 barrels in its second year, and 273,000 in its third year. The plan's programs did not receive full funding and therefore savings, while significant, fell short of the projections.

The most effective oil-reducing residential strategies consist of energy audits and strategies enabled by these audits, such as weatherization and insulation, and installation of efficient heating systems (including conversion to other fuels) through the Home Energy Savings Program ("HESP"). Business strategies include installation of efficient boiler and hot water heaters, and custom programs designed to serve specific process heating and geared toward saving liquid fuels, including conversion to biomass. It is important to note that the document is a plan for action with ultimate achievement of these targets dependent on a number of factors, notably continued funding of these programs. As discussed in the report (and confirmed during the stakeholder process), federal stimulus funds from the 2009 American Recovery and Reinvestment Act (or "ARRA") were used to fund much of these programs in FY2011. As these funds run out, additional funds will be necessary to continue programs directed toward liquid fuels that assist in reduction of oil dependence.

**2011 and 2012 Annual Reports of the Efficiency Maine Trust**

There have been two annual reports (documenting the experience of the program activities during FY 2011 and FY 2012) released by the Trust describing the Trust's program activities and energy saving results. While the reports trace the significant oil savings that were achieved in a series of boiler replacements at large industrial and smaller commercial facilities, particular focus is paid to three novel program initiatives aimed at helping residential customers to lower their oil bills.

<u>Home Energy Savings Program – Retrofit Rebates</u>

Under this limited-time rebate program, funded with a federal ARRA grant, homeowners had access to rebates if they performed home energy upgrades that achieved minimum energy saving levels. Nearly 5,000 Maine homes established their eligibility for the rebates by having energy audits performed, and the energy audits were paid for by the homeowners. Subsequent to the audits, more than 3,000 homeowners insulated the envelope of their homes and installed

more efficient heating equipment, achieving the minimum savings thresholds. These homes are now estimated to be saving more than one million gallons of oil per year. Homeowners also report having fewer drafts, ice dams and frozen pipes. The average home that participated in this program is projected to save 35%-40% on energy, or more than $1,400 per year assuming average oil consumption and prices as of 2011. After factoring in the total cost of the upgrades (the incentive from Efficiency Maine, the homeowner payments for the energy upgrades, and program delivery), the cost of the energy that will be saved over 20 years is equivalent to $1.16/gallon of heating fuel—a metric that is used in a later chapter. Moreover, the combined economic activity in the home builder / supplier / contractor trades generated by this program is estimated at more than $28 million. Summary energy saving benefits and costs are shown in Table 2 below.

**TABLE 2:** HOME ENERGY SAVINGS PROGRAM RESULTS (1/1/10-9/30/11)

| Total Units | Lifetime Savings (MMBTU) | Efficiency Maine Costs | Participant Cost | Lifetime Energy Benefit | Benefit-To-Cost Ratio |
|---|---|---|---|---|---|
| 3127 | 4,820,173 | $8,588,496 | $20,368,825 | $101,335,965 | 3.50 |

<u>PACE Loan Program</u>

Through the end of Fiscal Year 2012, 133 municipalities had opted into the PACE program. 1,172 loan applications had been received by Efficiency Maine Trust, resulting in 236 loans borrowing just over $3 million. The average PACE loan amount was $12,739 and the average project financed through the program was calculated to save 40% compared to its prior energy consumption levels.

<u>Replacement Heating Equipment Program</u>

From June 2011 to December 2011, more than 1,000 homeowners selected energy efficient heating system components, encouraged by a financial incentive provided by Efficiency Maine's Replacement Heating Equipment Program. As with the Retrofit Rebates and PACE Loans, this program was funded by ARRA. The energy saved over the full life of the installed measures is estimated to be the equivalent of 2.7 million gallons of heating oil (see Table 3).

**TABLE 3:** REPLACEMENT HEATING EQUIPMENT PROGRAM RESULTS

| Total Units | Lifetime Savings (MMBTUs) | Efficiency Maine Costs | Participant Costs | Lifetime Energy Benefit | Benefit-to-Cost Ratio |
|---|---|---|---|---|---|
| 1,198 | 373,728 | $ 1,373,142 | $ 456,127 | $ 9,813,721 | 1.34 |

A comparison of the two reports yields interesting observations about the focus on oil reduction strategies. The FY2011 activities directed toward all fuels[10] (including oil) cost approximately $20 million leveraged $46.8 million in participant investment and resulted in over 5.8 million mmbtu in lifetime savings, corresponding to a benefit cost ratio of 4.8[11]. By contrast, spending on the FY2012 fuel-blind activities was only $1.8 million, leveraging $4.6 million in participant savings. Due to the reduced funding, savings were much lower—363,589/52,425 mmbtu in lifetime/annual. Conversion of this latter (annual) savings number to barrels yields approximately 9.4 thousand barrels, which is significantly lower than the FY2012 targets set out in the plan that were described above. We provide more discussion of energy efficiency strategies in a later chapter.

**Triennial Plan of the Efficiency Maine Trust, 2014-2016**

The Trust recently completed its planning phase for efficiency programs covering the 2014-2016 time period. The second triennial plan continues the theme discussed above: there are significant savings that can be accessed in order to reduce Maine's oil dependence, but achievement of these savings will depend on the availability of funds (and assuming similar performance to past programs). Similar to the first triennial plan, the 2014-2016 plan contains a discussion of strategies that could be implemented to set the state on the path toward attainment of the oil-reduction targets specified in the Act. In particular, the 2014-2016 plan introduces a strawman proposal for a strategy to meet the goal of 100% weatherization of Maine by 2030. The strawman proposal carries a 3-year cost of $64 million, which would result in weatherization of 40,000 homes and a 20% average savings per home (or 8 trillion btu by 2020). The plan outlines the potential energy and cost savings of such a program but does not identify the funding source. We discuss and compare the costs of such programs with other options in a later chapter.

Taken together, the literature review shows a distinct evolution in implementing policies to reduce oil usage, which has shown up in decreases in usage that are expected to continue (discussed in the next section). Clearly, market forces have led customers to be more active in seeking their own solutions. Technology and infrastructure development in alternative fuels and increased use of these fuels, including natural gas, pellets, and heat pumps have been spurred by the run-up in distillate prices. In addition, the state has expanded their energy efficiency efforts (including supporting an industry and set of vendors to implement energy efficiency measures) to encompass all fuels and to leverage various sources of funds. These efforts include direct

---

[10] This includes incentives and financing for home energy upgrades, grants to municipalities and commercial customers for all fuels projects ranging from improvements to the building envelope to switching heating systems, as well as competitively bid projects at Maine's largest industrial sites, universities, and hospitals (including oil boiler replacement projects).

[11] The Home Energy Savings Program ("HESP"), which provides audits and rebates for home energy retrofits and weatherization, accounts for the vast majority of these savings and delivered energy savings at the cost of $1.16/gallon. Current heating oil prices in Maine are between $3.50 and $4.00/gallon.

assistance (through loans, grants, and rebates) to customers and education and outreach (including working with community colleges to assist in training).

## 2.2 CALCULATING THE BASELINE

In order to calculate the targets described in the Act and develop a list of strategies, we calculated a baseline level of consumption through the study period (2007-2050). Ideally, this baseline should reflect consumption of oil under "business as usual" conditions in terms of state policies in order to examine the potential impact of implementation of state policies and programs. Of course, any forecast of baseline consumption should assume that private actors will react to market conditions as permitted by current supply and infrastructure conditions. The *2013 AEO Early Release* Reference case was used for this calculation. The AEO 2013 provides forward-looking data at the national and regional level for consumption, production, and other energy system metrics across a variety of fuels. More importantly, the AEO essentially assumes existing policy environments (at both the federal and state levels).

As a result of using the AEO forecast, all analysis performed is examined by the various energy sectors as defined by EIA—residential, commercial, industrial, and transportation. The EIA defines each customer class as follows:[12]

- **Residential**: The residential sector is defined as private household establishments which consume energy primarily for space heating, water heating, air conditioning, lighting, refrigeration, cooking and clothes drying. The classification of an individual consumer's account, where the use is both residential and commercial, is based on principal use. Apartment houses are also included.
- **Commercial**: The commercial sector is generally defined as nonmanufacturing business establishments, including hotels, motels, restaurants, wholesale businesses, retail stores, and health, social, and educational institutions. The utility may classify commercial service as all consumers whose demand or annual use exceeds some specified limit. The limit may be set by the utility based on the rate schedule of the utility. Distributed generation located behind the meter in commercial buildings would be included in this category.
- **Industrial**: The industrial sector is generally defined as manufacturing, construction, mining agriculture, fishing and forestry establishments Standard Industrial Classification (SIC) codes 01-39. The utility may classify industrial service using the SIC codes, or based on demand or annual usage

[12] EIA http://www.eia.gov/cneaf/electricity/page/glossary.html#st

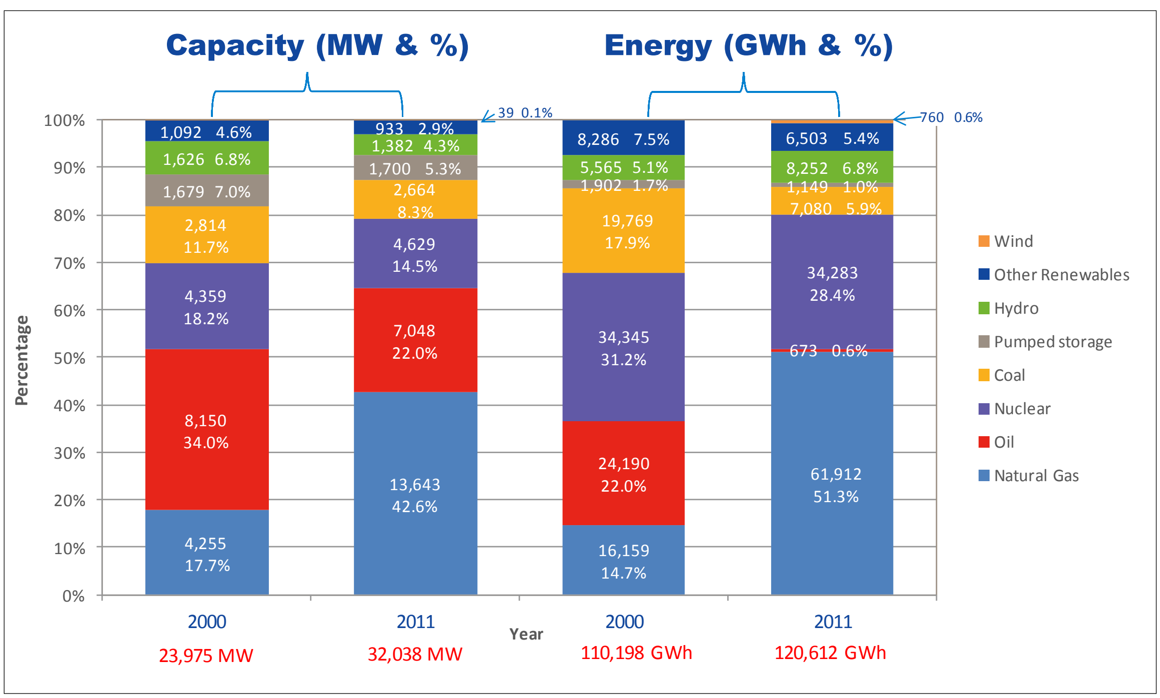
exceeding some specified limit. Distributed generation located behind the meter at industrial sites would be included in this category.

- **Transportation**: The transportation sector primarily includes passenger travel and freight movements. Passenger travel vehicles consist of light-duty vehicles (automobiles, motorcycles, and light trucks) and high-duty vehicles (buses, airplanes, boats, and trains). The freight modes of transport include truck, air, rail, pipeline, and marine (domestic barge and cargo).

It is important to note that the electricity consumption is embedded in each of the energy sectors. Thus, electricity usage for household lighting is included in the residential energy sector estimates. In terms of this study, we will not analyze oil use in electricity, thereby assuming that the electricity consumption by the sectors listed above is not significant.

Figure 2 compares 2000 and 2011 available capacity and actual generation of electricity by fuel in New England. Though New England continues to maintain some ability to burn oil for electricity generation, actual use of oil is virtually non-existent (based on 2011 data), undoubtedly due to the elevated cost of oil causing dispatch of cheaper generation. As a consequence of expected elevated prices for oil relative to other fuels (see Figure 4) and limited oil usage – effectively a phasing out of oil usage for electricity generation—we do not consider strategies directed toward reducing electricity usage (and by association, generation).

**FIGURE 2:** NEW ENGLAND ELECTRIC CAPACITY AND ENERGY, 2000 AND 2011




Source: ISO-NE 2012 Regional System Plan, Figure 7-4

Historical state-level data for Maine was used from SEDS to establish 2007-2010 consumption levels. Due to lack of state-level forecasts, forecasted baseline consumption for 2011-2040[13] was determined by applying the EIA's 2013 *AEO Reference Case - New England* region change in growth to 2010 historical SEDS data for Maine. In order to be conservative, we assumed the forecasted baseline consumption levels for 2041-2050 would remain constant at 2040 levels; an alternative would be to assume continued declines in oil consumption, which would reduce the targets further.

Oil consumption by sector is shown for 2007-2050 in Figure 3 along with the 2030 (29.6 million barrels) and 2050 (21.1 million barrels) target goals for reducing Maine's consumption of oil by at least 30% from 2007 levels by 2030 and by at least 50% from 2007 levels by 2050. The EIA forecasts assumes significant decreases in oil usage in the transportation sector (largely due to federal fuel efficiency standards as discussed in a later section), which accounts for the largest amount of the forecasted decrease.

Figure 3 shows that, based currently anticipated market conditions (and the differential between natural gas and oil prices), the 2030 target should be attained without significant additional state policies or programs. On the other hand, 2050 requires implementation of additional strategies. Of course, any reduction in use of a relatively high priced fuel will have beneficial impacts, thus state action to provide incentives and support use of cheaper fuels is warranted if deemed cost-effective.

[13] The AEO 2013 forecast period ends in 2040.

**FIGURE 3:** MAINE'S BASELINE OIL CONSUMPTION FORECAST, 2007-2050[14,15,16]

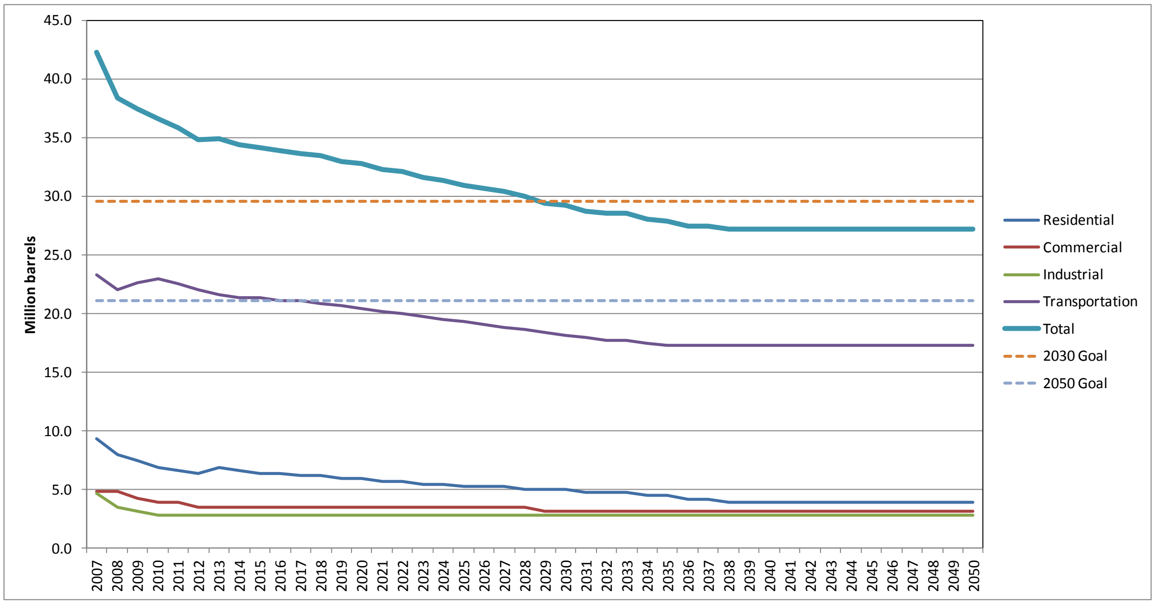


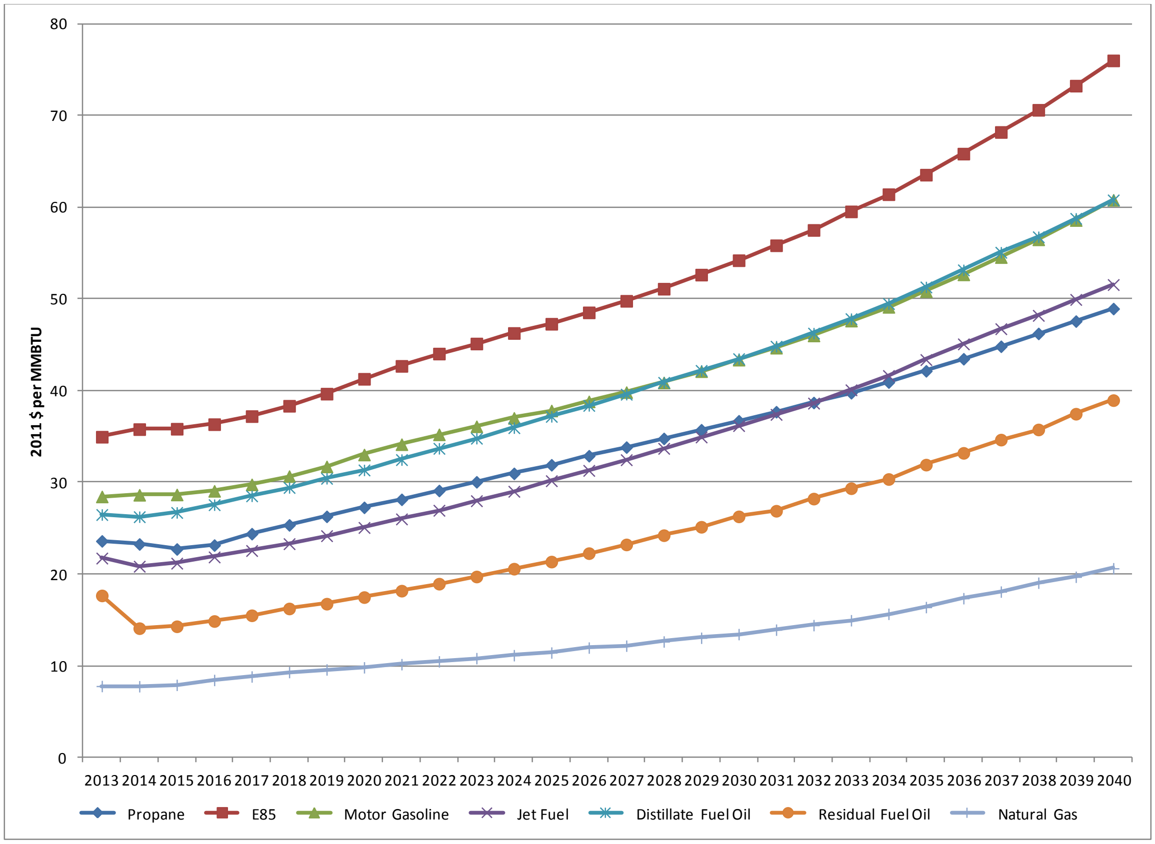

Figure 4 on the next page shows the price assumptions underlying the baseline oil consumption forecast. Liquid fuel prices are assumed to stay high relative to natural gas, thus switching to lower-cost fuels will have significant economic benefit to Maine's consumers and businesses based on this price outlook. The figure does show that the spread between propane and distillate fuel oil is expected to grow.

[14] Data gathered from AEO Table Browser – Energy Consumption by Sector and Source, New England Region Table. EIA 2013 AEO Reference Case. http://www.eia.gov/oiaf/aeo/tablebrowser/

[15] Data gathered from EIA State Energy Data System (SEDS). http://www.eia.gov/beta/state/seds/seds-data-complete.cfm?sid=ME

[16] Conversion factors used to convert units from mmbtu to barrels of oil are found in Appendix G of the *2012 Annual Energy Outlook.* http://www.eia.gov/forecasts/aeo/pdf/appg.pdf

**FIGURE 4:** AVERAGE PRICE TO ALL USERS BY FUEL




## 2.3 PROGRESS TOWARD TARGET LEVELS

We calculated the necessary target reductions to meet the requirements of the Act. Based on the outlook presented above and using historical data for Maine, a 30% reduction from 2007 levels is equal to a total consumption of oil of 29.6 million barrels while a 50% reduction results in total oil consumption of 21.1 million barrels (see Table 4).

**TABLE 4:** MAINE CONSUMPTION TARGET REDUCTION LEVELS[17]

| *million barrels equivalent* | 2000 | 2003 | 2005 | 2007 | 2010 | 2030 Target | 2050 Target |
|---|---|---|---|---|---|---|---|
| **Residential** | 9.3 | 11.1 | 11.1 | 9.4 | 6.9 | | |
| **Commercial** | 4.2 | 5.0 | 4.7 | 4.9 | 3.9 | | |
| **Industrial** | 7.0 | 4.9 | 6.1 | 4.7 | 2.8 | | |
| **Transportation** | 22.1 | 24.1 | 24.2 | 23.3 | 23.0 | | |
| **Total Oil Consumption** | 42.6 | 45.1 | 46.0 | 42.3 | 36.6 | 29.6 | 21.1 |

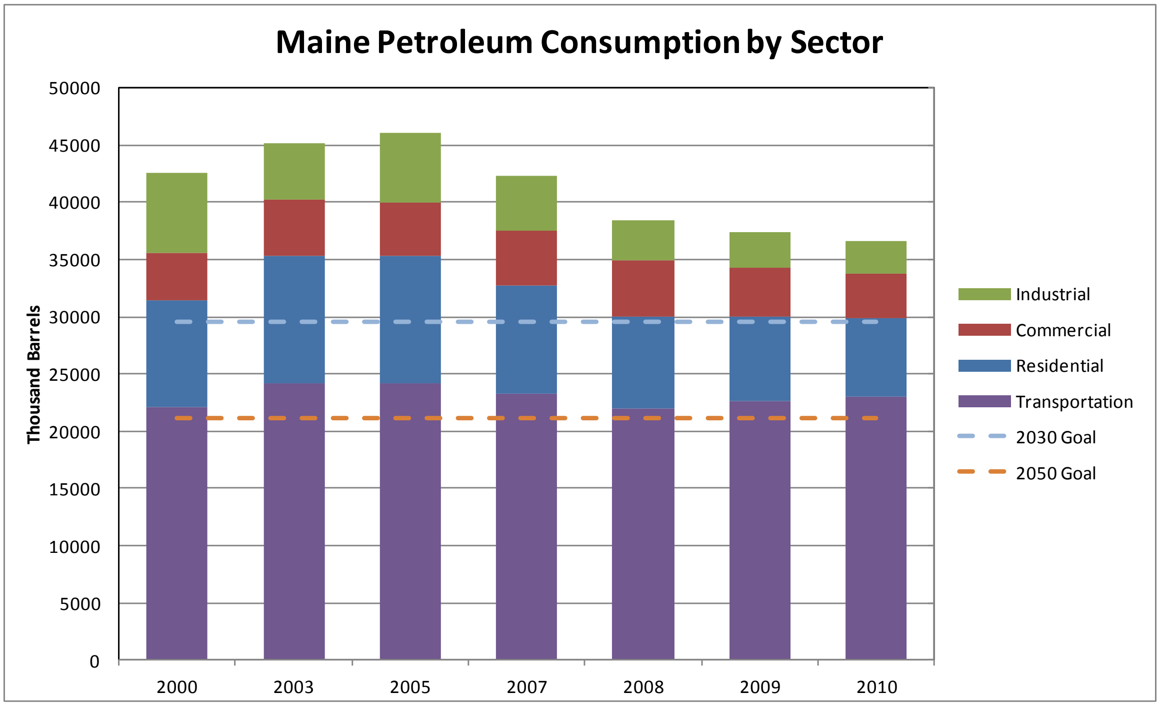
Source: EIA SEDS, Author

The table shows that there has been progress since 2007, with over a 5.5 million barrel oil reduction in just three years. It is beyond the scope of the current study to fully explain the increase through 2005, but since 2007, there appears to be clear evidence of fuel switching from oil and greater efficiency in oil usage. Clearly, the economic downturn has had some impact on overall energy usage (not just oil usage), but there have also been signs of significant consumption reductions in the industrial sector in particular. For example, data from the Maine Department of Environmental Protection show reductions in oil usage in 2011 compared to pre-recession 2007 levels, and stakeholders indicated significant efforts in conversion and energy efficiency efforts across all sectors except for transportation.

Indeed, the differential between oil and natural gas prices has led households and businesses (especially) to seek different fuels. In Figure 5 below, the petroleum consumption by sector for Maine is shown for each year in the 2007-2010 time period. While significant progress has been made towards reducing Maine's overall petroleum consumption, some sectors have had larger reductions than others. For example, while decreases in the residential sector over this period have been about 26%, the industrial sector enjoyed about a 40% decrease in petroleum consumption from 2007 to 2010. The commercial sector also featured significant a significant decrease of over 20%. Unfortunately, use of petroleum (diesel and motor gasoline) in the transportation sector continues to be prominent, as this sector only had a 1.6% decrease in total petroleum consumption from 2007 to 2010.

[17] Data gathered from EIA State Energy Data System (SEDS). http://www.eia.gov/beta/state/seds/seds-data-complete.cfm?sid=ME

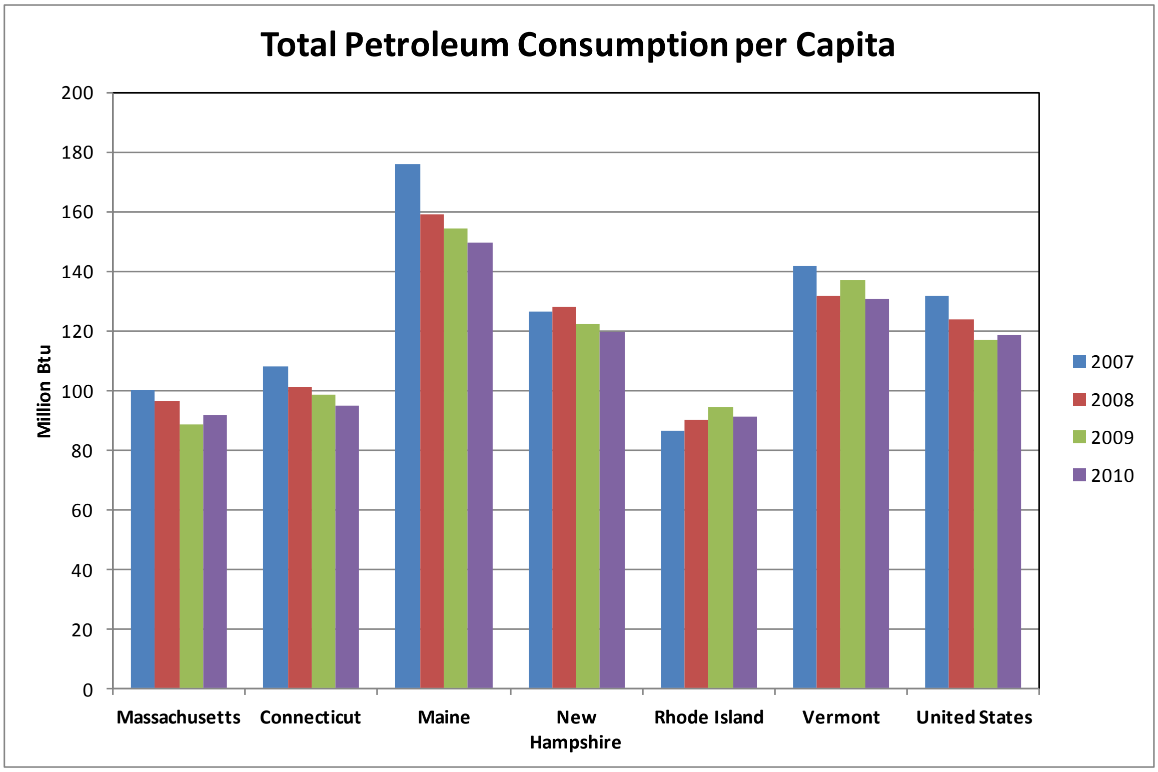
**FIGURE 5:** MAINE PETROLEUM CONSUMPTION BY SECTOR, 2007-2010[18]




In Figure 6 below, the total petroleum consumption per capita is shown for New England states as well as the United States for years 2007-2010. Maine continues to have the highest consumption per capita compared to all other New England states (mostly because of transportation usage). However, Maine has also significantly reduced its per capita petroleum consumption between 2007 and 2010. Targeting strategies at the transportation sector would serve to decrease this consumption even further.

[18] Data gathered from EIA State Energy Data System (SEDS). http://www.eia.gov/beta/state/seds/seds-data-complete.cfm?sid=ME

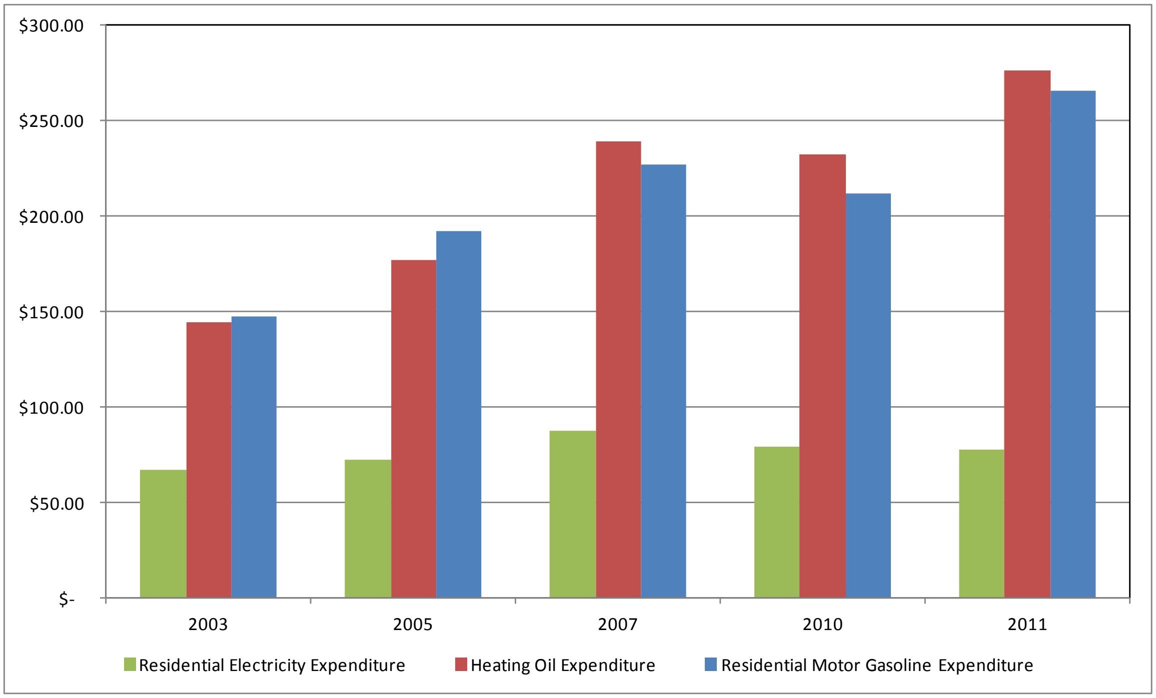
**FIGURE 6:** TOTAL PETROLEUM CONSUMPTION PER CAPITA FOR NEW ENGLAND STATES, 2007-2010[19]




In Figure 7 below, the monthly expenditure per Maine household is shown for residential electricity, heating oil, and motor gasoline consumption for select years. In general, heating oil expenditures for Maine households has followed a strong upward trend since 2003. While in contrast to the decreasing trend in petroleum consumption per capita shown in the figure above, the increase in expenditure for heating oil fuel is reflective of the increase in heating oil prices and Maine's continued dependency on oil. Gasoline prices have also risen and account for the increase in household expenditure over time. By contrast, residential electricity expenditures reached a peak in 2007 and have fallen over time as generation costs have decreased and overall energy efficiency in electricity has improved.

[19] Data gathered from EIA State Energy Data System (SEDS). http://www.eia.gov/beta/state/seds/

**FIGURE 7:** MONTHLY ELECTRICITY, HEATING OIL, AND GASOLINE EXPENDITURES PER MAINE HOUSEHOLD[20] [21] [22] [23]




## 2.4 CURRENT POLICIES AND PROGRAMS AND BASELINE CONSUMPTION

Key assumptions used to derive this baseline forecast for Maine's oil consumption are described by energy sector in the following sections. We first describe existing state policies and programs that are targeted specifically at oil reductions that may not have been explicitly included in the baseline consumption forecast. We then provide an overview of some of the major assumptions and highlights underlying the 2013 AEO Reference Case that was shown above.

[20] Electricity expenditure data from EIA

[21] Heating oil expenditure assume average annual consumption of 900 gallons of heating oil; prices taken from Maine Governor's Energy Office Archived Heating Fuel Prices, http://www.maine.gov/energy/fuel_prices/archives.html

[22] Motor gasoline expenditure from SEDS Database, table ET2, Total End Use Energy Price and Expenditure Estimates, 1970-2010, Maine. Residential motor gasoline expenditure taken at 95% of total end use reported in SEDS based on analysis of FHA Highway Transportation Energy Consumption by Mode data.

[23] 2011 motor gasoline expenditure extrapolated from percentage difference in 2010 compared to 2011 average motor gasoline prices for New England reported in Clean City Alternative Fuel Price Reports, available here: http://www.afdc.energy.gov/publications/#search/keywork/?q-alternative fuel price report.

### 2.4.1 *STATE POLICIES AND PROGRAMS*

Maine's current policies and programs to reduce oil usage are somewhat limited compared to programs geared toward reducing electricity and natural gas consumption. Programs are not focused on reducing residential heating costs where there is significant oil usage. As discussed in the literature review, the relative lack of focus on oil programs appears more related to the sources of funding for these programs and policies and the limitations on use of the funds rather than the belief that oil-reduction strategies are less beneficial. Notwithstanding this observation, we describe the recent attention to oil usage, especially through programs promoted by the Trust (and funded through federal stimulus monies) and discuss whether such programs should be considered in the baseline consumption forecast. The goal of this section is not to provide an exhaustive discussion of all existing policies and programs geared toward oil reduction, but to explain why we did not include adjustments to the baseline forecast based on state policies and programs that may have not been included in the baseline consumption levels of Figure 3.

The most significant set of programs and/or policies to date have been the various Energy Efficiency Trust programs directed toward reducing oil usage. As discussed above, HESP and replacement of inefficient heating equipment (both targeted at residential customers), installation of renewable systems (e.g., wood pellet boilers at institutional customers), and assistance with fuel conversion efforts for commercial, institutional, municipal[24], and industrial customers have all provided oil reductions. Given that most of the funds directed toward oil reduction strategies have been exhausted, the Trust has directed interested parties to their "PACE" loan program, which provides low-interest[25] loans to homeowners. Low-interest loans were also available for small businesses through a separate program but funds were exhausted and on-bill financing options are being pursued.

The above programs had significant oil reduction impacts during the first two years of the Trust's first triennial plan, and continuation of some of these programs has been recommended in the next three-year plan, but funding is uncertain. As a result, we did not include savings from these potential programs in the baseline consumption forecast. The baseline forecast assumes some reduction over the forecast period, thus we assume that the reductions from the first triennial planning period are included in the baseline forecast without further adjustment. Finally, we acknowledge that Maine has other initiatives, such as building codes and energy standards for public buildings, but we were unable to locate documentation or analysis of oil reduction benefits from them.

[24] The Energy Efficiency and Conservation Block Grant (EECBG) program is a federally funded program to assist municipal and county governments to pursue energy efficiency improvements, which include replacement of inefficient boilers and other heating equipment.

[25] Current rates for this program are 4.99% (with no closing fees), which is low compared to certain loan types, and has the benefit of a longer term (10-15 years) and fixed rate, but is higher than home equity line of credit loans for qualified homeowners.

Maine utilities also feature programs, such as the heat pump pilot program (Bangor Hydro in partnership with Efficiency Maine) and pilot programs for electric vehicles. Given the size (and pilot nature) of these programs, we also did not adjust the baseline for these initiatives.

A final set of policies are more related to alternative fuel usage in the transportation sector. In terms of financial incentives, Maine offers a $0.05/gallon income tax credit to biofuel producers and exempts individuals who produce biofuels for their own use from the state excise tax. Maine does have different tax rates for different fuels, but the rates are quite close after adjusting for the heat content of different fuels. Moreover, as discussed above, there are state requirements and funding sources for purchases and use of alternative vehicles by state agencies and staff.

Finally, the Clean Cities program in Maine provides a number of incentives to assist switching to alternative fuels, including support for alternative fuel delivery and fueling infrastructure, but these programs are almost all funded with federal monies. These programs play a critical role in developing potential alternatives to oil consumption in the transportation sector, but we assume they are already embedded in the baseline forecast given that they have been in existence for some time.

### 2.4.2 *RESIDENTIAL*

Historical and forecasted energy consumption data by different resources for Maine's residential sector is shown in Figure 8 below. Historical data for Maine is taken from EIA SEDS and forecasted using EIA *2013 AEO Reference Case - New England* region trends applied to 2010 SEDS values for Maine. The goal of the analyses in the next few sections is to examine whether the baseline forecast for each sector assumes reductions in petroleum usage (either through more efficient usage of petroleum or conversion to alternative fuels) in order to provide some insight into resource and strategy choices going forward.

Overall, natural gas consumption in the residential sector averages a 0.4% reduction annually in the New England region compared to a 0.5% annual reduction in the U.S. This comparison signals that the EIA does not assume a major conversion (and major distribution service build-out) effort in the region. As a result, additional reduction in oil usage from conversion to natural gas is an option that would contribute to meeting the target relative to the baseline consumption figures.

For the New England region, energy consumption in the residential sector from renewable (for all uses) grows at 0.1% annually. By contrast, renewables[26] consumption increases 6.4% annually for 2011-2040 in the U.S. This includes consumption from:

[26] Excludes biomass. Renewable energy consumption for the residential sector, which includes wood for residential heating, is expected to increase 0.1% annually during 2011-2040.

- Geothermal heat pumps increasing an average of 4.3% annually in the U.S.
- Solar hot water heating increasing an average of 1.6% annually in the U.S.
- Solar photovoltaic increasing an average of 8.1% annually in the U.S.
- Wind increasing an average of 7% annually in the U.S.

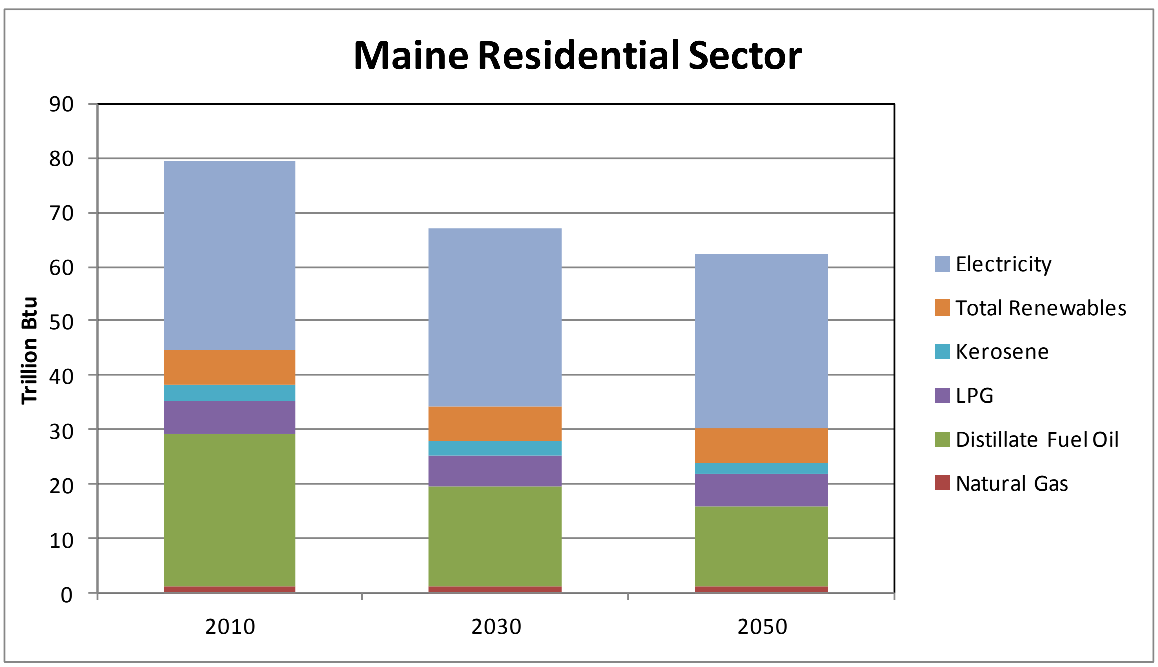
Possible reasons for the greater increase at the national scale is lower electricity prices (for use in geothermal heat prices) and greater availability of solar resources, which would tend to reduce the price of these renewable resources.

Delivered energy consumption by distillate fuel oil decreases 2.1% annually for 2011-2040 in the U.S. and in the New England region. This includes consumption used for:

- Space heating decreases an average of 1.9% annually in the U.S.
- Water heating decreases an average of 3.3% annually in the U.S.

These are two primary uses for oil in the residential sector and the equal percentage reductions forecasted for the U.S. and the New England region add credence to the lack of a large move away from oil systems for space or water heating. Indeed, Figure 8 shows that though distillate usage falls, there is not an increase in natural gas usage. Rather, propane and renewable (which includes wood) feature slight increases.

**FIGURE 8**: MAINE RESIDENTIAL SECTOR TOTAL CONSUMPTION, HISTORICAL AND FORECAST[27,28]




[27] Historical data from EIA State Energy Data System (SEDS). Forecasted data used SEDS and EIA 2013 AEO Reference Case, Energy Consumption by Sector and Source, New England Region.

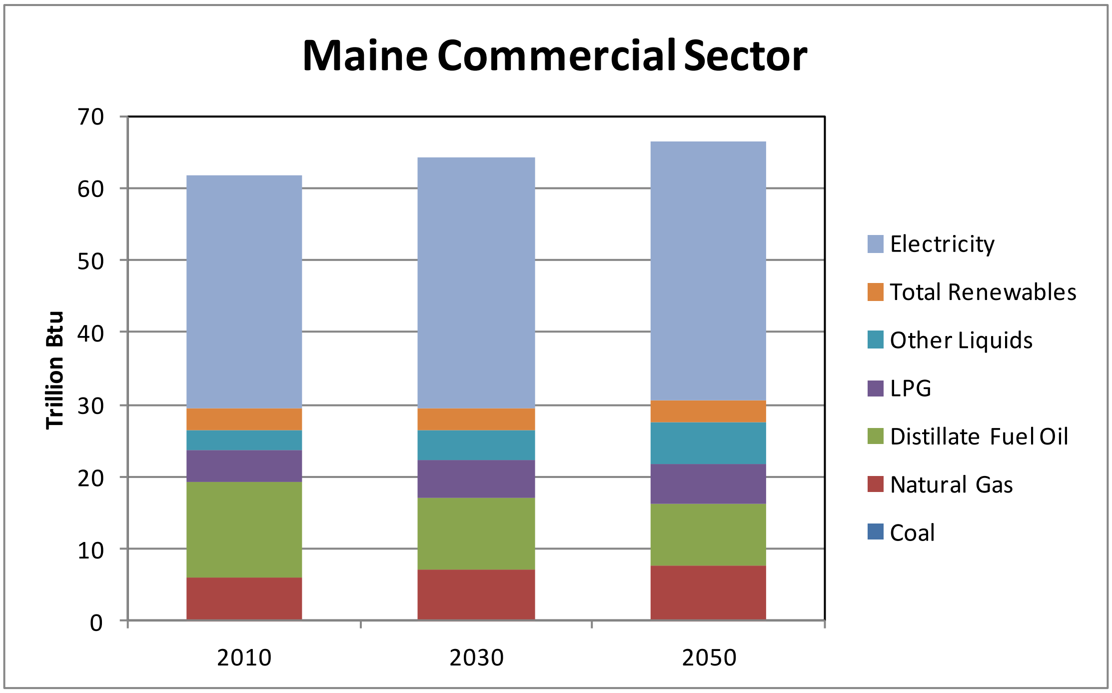
[28] Total renewables includes wood used for residential heating.

### 2.4.3 COMMERCIAL

Similar to the residential analysis shown above, historical and forecasted energy consumption data for Maine's commercial sector is shown in Figure 9 below. Total distillate fuel oil consumption in the New England region decreases 1.4% annually while delivered energy consumption by distillate fuel oil in the U.S. decreases 1.1% per year for 2011-2040. This includes consumption used for space heating, water heating, and other uses (notably for self - generation).

Unlike the residential sector, growth of natural gas consumption in the commercial sector averages 0.8% annually in the New England region compared to a growth of 0.4% annually for the United States. This increase in commercial natural gas consumption in New England may include additional use of combined heat and power and conversion to natural gas for space and water heating.

**FIGURE 9:** MAINE COMMERCIAL SECTOR TOTAL CONSUMPTION, HISTORICAL AND FORECAST[29,30]




## 2.4.4 *INDUSTRIAL*

For the industrial sector, EIA forecasts that total distillate fuel oil consumption in the New England region is to increase 0.5% annually, while delivered energy consumption by distillate fuel oil in the U.S. remains constant for 2011-2040. Based on review of Maine-specific data and input from stakeholders documenting progress toward oil reduction goals, we believe this outlook to be high. As a result, we maintained consumption at the 2010 levels shown in Table 4. Following this adjustment, historical and forecasted data for Maine's industrial sector are shown in Figure 10 below.

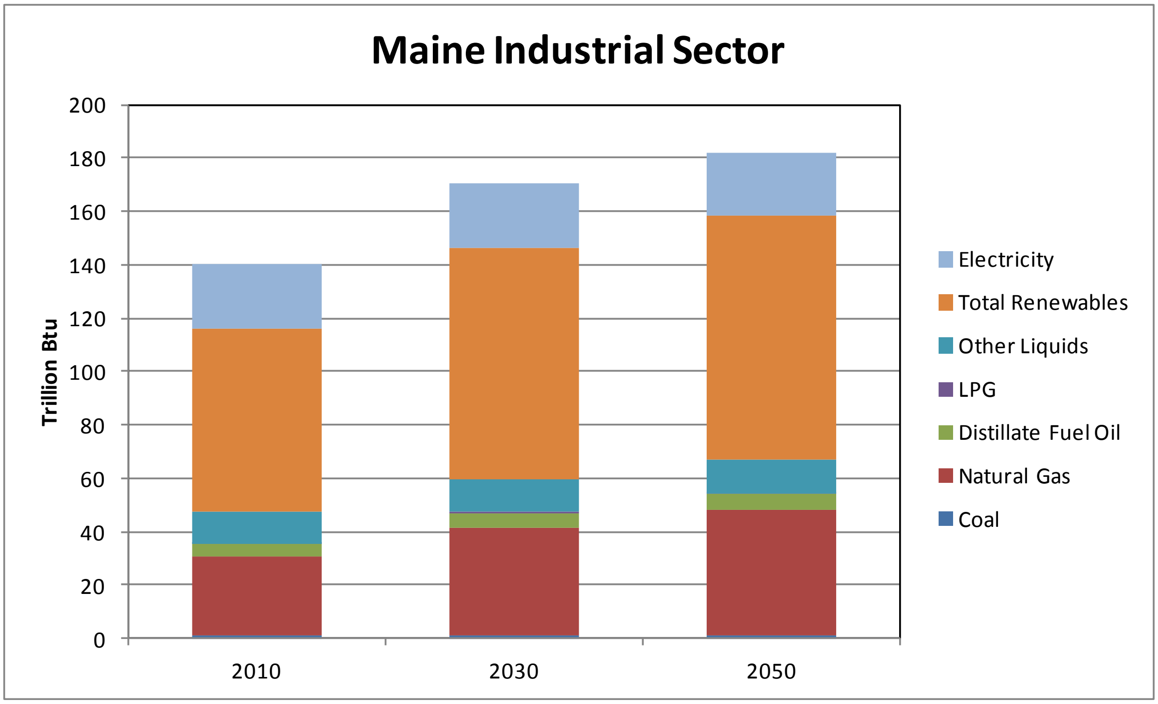
Change in natural gas consumption is expected to continue to grow in this sector, which featured the highest annual change in natural gas consumption of all the sectors. Natural gas energy consumption is forecasted to increase 1.8% annually in the New England region and 0.8% annually in the U.S. for 2011-2040. The total energy consumption is greater from 2011-2025 as the industry responds to lower natural gas prices in the near term. However, after 2025, increased international competition and rising natural gas prices lead to slower growth in industrial energy consumption.

[29] Historical data from EIA State Energy Data System (SEDS). Forecasted data used SEDS and EIA 2013 AEO Reference Case, Energy Consumption by Sector and Source, New England Region.

[30] Renewables exclude ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power.

For the New England region, energy consumption in the industrial sector from renewables grows at 1.9% annually while renewables grow at 1.4% annually in the U.S. in the industrial sector for 2011-2040. Overall, oil usage is expected to constitute a relatively small percentage of total industrial energy usage.

**FIGURE 10:** MAINE INDUSTRIAL SECTOR TOTAL CONSUMPTION, HISTORICAL AND FORECAST[31,32]




## 2.4.5 *TRANSPORTATION*

The *AEO 2013 Reference* case includes the greenhouse gas and corporate average fuel economy (CAFE) standards for light-duty vehicles through model year 2025. These standards increase new vehicle fuel economy from 32.6 miles per gallon (mpg) in 2011 to 47.3 mpg in 2025. The inclusion of these newly enacted standards reduces motor gasoline consumption in the transportation sector by 34.2% in 2040 from 2010 levels in New England.[33] The dip in total transportation consumption from 2010 to 2030, as shown in Figure 11, is primarily due to the CAFE standards taking effect. The rise from 2030 to 2050 in total transportation consumption is

[31] Historical data from EIA State Energy Data System (SEDS). Forecasted data used SEDS and EIA 2013 AEO Reference Case, Energy Consumption by Sector and Source, New England Region.

[32] Renewables includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol blends (15 percent or less) in motor gasoline.

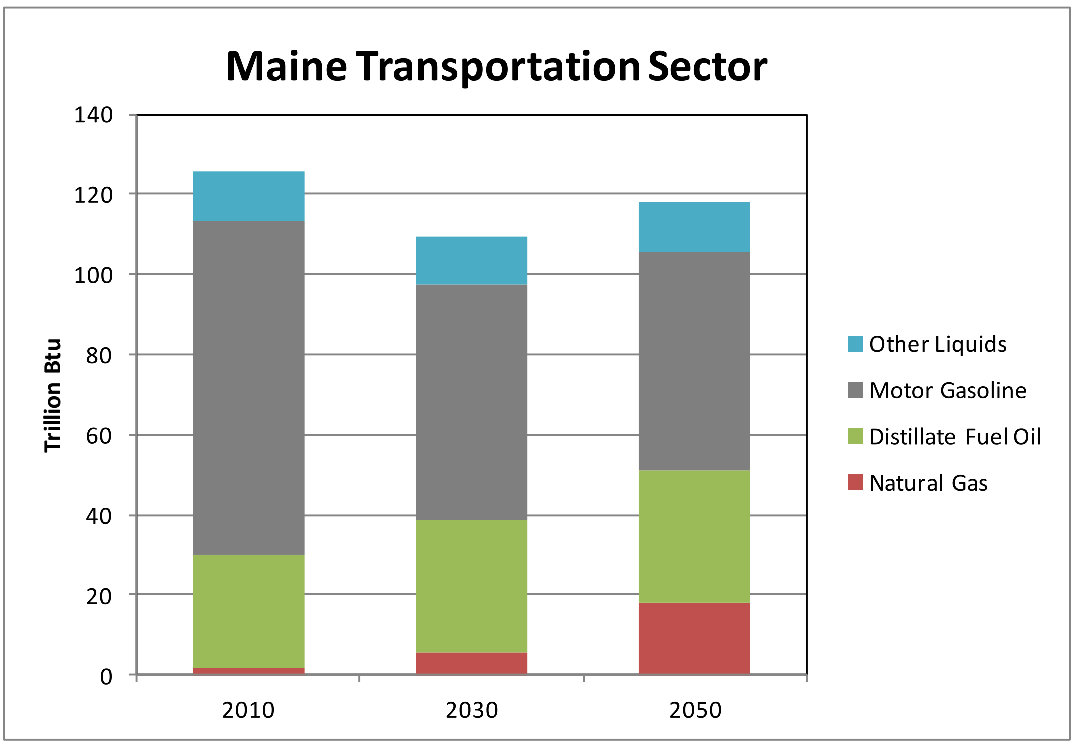
[33] EIA. 2013 AEO Early Release Overview. http://www.eia.gov/forecasts/aeo/er/early_consumption.cfm

primarily due to the increase in travel demand exceeding the fuel economy improvements from the enacted CAFE standards.

Motor gasoline consumption in the transportation sector in New England declines 1.3% annually during 2011-2040 while motor gas consumption in the U.S. declines 0.9% annually. Distillate fuel oil consumption increases 1.0% annually in the U.S. while growing at 0.6% annually in the New England region, signifying the continued role of diesel fuel in transportation. Electricity consumption in the transportation sector grows at 3.9% annually for the United States in 2011-2040 and 4.3% annually for the New England region. However, SEDS data show that electricity sales in the transportation sector are concentrated in a few states in New England. Maine has reported historical retail electricity sales of close to zero, which are reflected in the SEDS data.

It is interesting to note that compressed/liquefied natural gas energy consumption increases 13.5% annually for 2011-2040 in the New England region, thus assuming some buildout of fueling station and natural gas pipeline infrastructure, especially after 2030. Nevertheless, natural gas only reaches a maximum of 15% of total energy consumption in 2050.

**FIGURE 11:** MAINE TRANSPORTATION SECTOR TOTAL CONSUMPTION, HISTORICAL AND FORECAST[34]




[34] Historical data from EIA State Energy Data System (SEDS). Forecasted data used SEDS and EIA 2013 AEO Reference Case, Energy Consumption by Sector and Source, New England Region.

# 3. OIL REDUCTION OPTIONS

A comprehensive list of possible oil reduction options by sector was determined by leveraging existing information and resources, including input from stakeholders, as well as industry knowledge. Below we present an overview of these options by three sectors—residential, commercial/industrial, and transportation. Though we acknowledge that industrial usage in Maine can be significantly different from commercial usage (in terms of the composition of the economic sectors), the strategies related to oil reduction are similar in design (though different in scale). In addition, the industrial sector has made the most progress towards meeting oil reduction goals, thus greater focus should be placed on strategies that address oil usage in the residential and, especially, transportation sectors.

Generally speaking, reduction in oil usage is accomplished through either (1) decreases in overall usage through more efficient usage of oil or (2) decreases in oil usage through use of alternative fuels. The first group of strategies relates to efficiency of usage and largely consists of energy efficiency strategies, such as weatherization of residences and businesses and installation of more efficient oil-burning equipment. The second group of strategies relates to conversion from oil to another fuel, notably natural gas. State action (through policies, programs, regulation, and legislation) can impact these strategies and are highlighted below.

Table 5 compares the baseline consumption levels to the 2030 targets in total. The baseline forecast (Figure 3) as adjusted for the discussion in the prior chapter shows oil consumption in Maine at 29.2 million barrels in 2030, signifying that the 2030 target goal is attainable based on anticipated market conditions and the current Maine policy environment. Though the transportation sector is not expected to meet the target, consumption reductions in other sectors exceed the 30% 2030 target reduction, which causes overall consumption to be below the 30% reduction target level.

By contrast, Maine's oil consumption is forecasted at 27.2 million barrels in 2050, resulting in a target reduction of 6.1 million barrels in order to meet the 2050 goal. Most of the reduction needed to meet this long-term goal would need to occur in the transportation sector.

**TABLE 5:** BASELINE CONSUMPTION COMPARE TO TARGET LEVELS, 2030 AND 2050

| *million barrel equivalent* | 2030 Baseline | 2030 Target | 2050 Baseline | 2050 Target |
|---|---|---|---|---|
| **Residential** | 5.0 | | 3.9 | |
| **Commercial** | 3.2 | | 3.2 | |
| **Industrial** | 2.8 | | 2.8 | |
| **Transportation** | 18.2 | | 17.3 | |
| **Total Oil Consumption** | 29.2 | **29.6** | 27.2 | **21.1** |

Interestingly, the data show that between 2030 and 2050, residential oil consumption is expected to fall[35] while commercial oil usage is expected to stay constant. Industrial oil usage was assumed to stay constant, which may be conservative based on recent trends, but represented a departure from the EIA forecast that projected an increase in oil usage among industrial customers over the forecast period. Based on existing market and policy conditions, the data show that the transportation sector requires the most attention from policymakers. Of course, state policy can assist with the speed of adoption of oil reduction strategies and overcoming barriers, such as financing of capital and upfront outlays.

## 3.1 RESIDENTIAL

Oil usage in the residential sector is primarily used for space heating and water heating. As previously discussed, Maine features the highest percentage of households that have oil heat as their primary heating source. Strategies to address this dependence have been proposed and analyzed for quite some time, with recent extensive implementation due to availability of federal funds. Strategies can be categorized into three broad groups:

- Replacement of existing boilers, furnaces, and water heaters with more efficient equipment and configurations;
- Weatherization of existing housing stock including air sealing and insulation that result in more efficient use of fuel; and
- Conversion of existing oil equipment to an alternative fuel. Alternative fuels include biomass (wood and wood pellets), natural gas, electric (using heat pumps), geothermal, and biodiesel. Solar can also be used for water heating purposes. It is important to note that conversion to an alternative fuel may not necessarily increase the efficiency in energy usage.

The first two groups influence the use of the existing fuel, thus no additional energy distribution infrastructure (in the community or inside the building) is necessary, and the second group generally requires no major capital expenses. The third group may need additional infrastructure for certain fuels (such as pipeline gas).

The Efficiency Maine Trust, Maine State Housing Authority and the Community Action Agencies have been heavily involved in assisting homeowners in implementing the first two groups of strategies through a number of programs and policies:

- Recruiting and training of energy auditors to support education of consumers and delivery of the program to consumers;

[35] EIA expects all residential energy consumption to fall (see Figure 3), hence all fuel types feature a decrease in the 2010-2050 time period.

- Rebates (some tied to extent of efficiency improvements) to defray upfront or capital costs of air sealing, insulating, and replacement heating systems that are more efficient or use different fuels;
- Education and marketing programs to broadcast the benefits and the availability of rebates to support efficiency and/or conversion efforts;
- Training of heating, ventilation and air conditioning ("HVAC") professionals and vendors on new technologies, installation and maintenance techniques, and sales strategies; and
- Low-interest financing and/or on-bill financing, which allows homeowners to pay for efficiency and/or conversion equipment through zero or low-interest loans repaid through their monthly electric or natural gas bills (from the respective local distribution company).

## 3.2 COMMERCIAL AND INDUSTRIAL

Commercial and industrial uses for oil are similar in type (space and water heating) to residential, but industrial sector uses also include process heat used in manufacturing processes. Though not at the scale of the programs targeted to residential customers, the state (through Efficiency Maine Trust) has provided assistance to businesses to retrofit buildings and install more efficient boilers and/or convert to alternative fuels.[36]

Use of combined heat and power (CHP) is one option that could be pursued by commercial and industrial customers. Though use of CHP requires certain customer characteristics—notably the need for year-round (or close to year-round) thermal energy, the benefits can be large and this technology has been shown to be cost-effective.

Though certain CHP qualifies for Maine's current renewable portfolio standard (Class II), these facilities do not qualify for the more lucrative Class I (new resources) renewable energy credit (REC) revenue. Achievable potential in Maine appears limited, due to lack of fuel and available incentives. The thermal production from these facilities[37], which are almost all powered by natural gas or biomass, could serve as another potential oil reduction strategy for larger customers by displacing existing oil usage. One of the important limitations to achieving additional CHP is availability of fuel (notably natural gas). As natural gas availability expands, we can expect the amount of achievable potential to increase. In addition, the development of compressed natural gas is a very encouraging development for more rural commercial and industrial businesses.

[36] Funds from the Regional Greenhouse Gas Initiative (RGGI) were used to fund many of the commercial and industrial initiatives.

[37] A 2012 Cadmus report for the Trust calculated technical potential of over 2100 facilities and 755MW. By contrast, achievable potential consisted of only 22 facilities and 12.5 MW.

## 3.3 TRANSPORTATION

Transportation strategies and options include variations on the types of options listed above but are more complex due to the network nature of the transportation system and the interactions with land use patterns. In transportation, energy usage is a function of vehicle miles traveled (VMT) much more so than energy output of the fuel (e.g., btus per gallon). Increasing vehicles per gallon of transportation vehicles or reducing overall VMT—through shifting of transportation modes that utilize alternative fuels or are more efficient in their passenger or freight mile delivery—are the goals when considering oil reduction strategies.

Given the extent of the reductions necessary to meet the target goal in the transportation sector, it is important to understand how the different transportation modes account for overall energy consumption. Table 6 shows the most recent data for transportation consumption by mode for Maine (adapted from national statistics).

**TABLE 6:** PETROLEUM USAGE BY TRANSPORTATION MODE, 2010

| | % of Total Petroleum Usage |
|---|---|
| **Air (Jet Fuel and Aviation Gasoline)** | 7% |
| **Highway (Gasoline and Diesel)** | |
| **Light duty vehicle, short wheel base and motorcycle** | 46% |
| **Light duty vehicle, long wheel based** | 19% |
| **Single-unit 2-axle 6-tire or more truck** | 8% |
| **Combination truck** | 16% |
| **Bus** | 1% |
| **Transit (Diesel and Gasoline)** | 0% |
| **Rail, Class I Freight (Diesel)** | 2% |
| **Amtrak** | 0% |

Source: Bureau of Transportation Statistics, Author

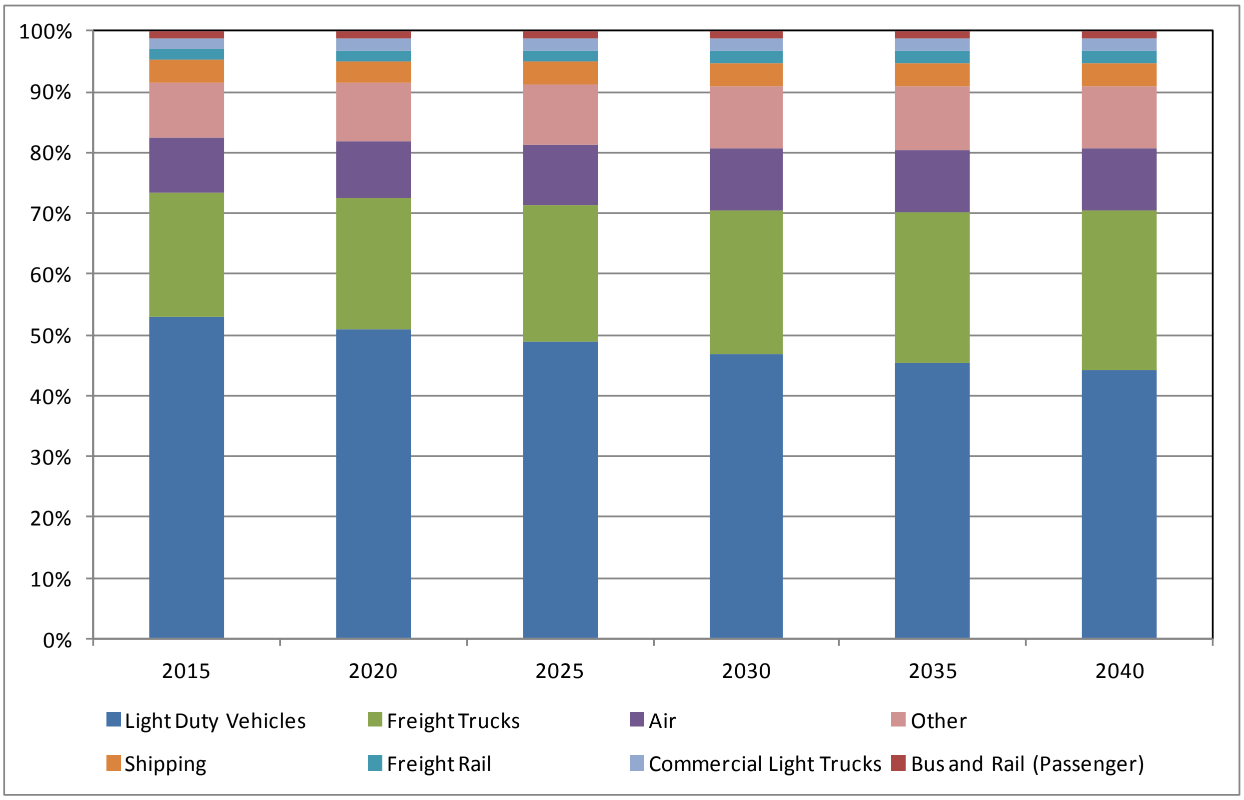
A great deal of fuel switching strategies in the transportation sector have been directed toward municipal and other fleet vehicles[38]—bus transit, trash haulers, school buses, etc. However, such vehicles account for a relatively small percentage of overall fuel usage. Combination trucks that are used for long haul freight accounted for nearly double the amount of energy used by

[38] For example, 40% of all trash haulers sold in the U.S. last year were powered by natural gas (CNG). Forbes, November 27, 2012.

smaller trucks, and one estimate shows that long-haul trucks use 10 times more diesel than trash trucks and buses combined.[39]

As described in the prior chapter, baseline consumption is forecasted to fall for the transportation sector, mostly due to improved efficiency standards for passenger vehicles. However, these standards to not apply to freight trucks and as shown in Figure 10, energy consumption from freight trucks increases significantly compared to other modes, reaching 25% of all energy usage in the transportation sector in 2040.

**FIGURE 10:** ENERGY CONSUMPTION BY TRANSPORTATION MODE, 2015-2040

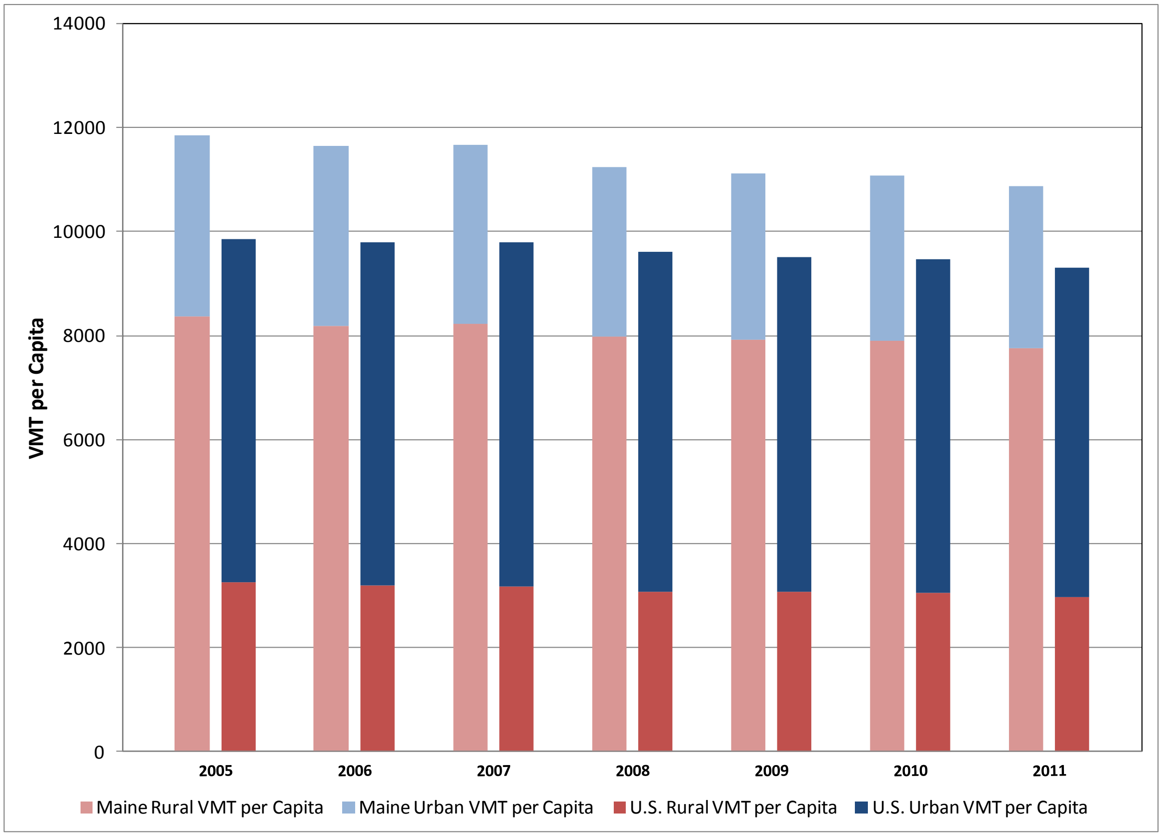



Source: EIA Annual Energy Outlook 2013 Early Release, Author

Figure 11 below shows the total VMT per capita for Maine and the U.S. for 2005-2011. It is interesting to note that VMT has been decreasing (as hinted to in the prior discussion on per capita energy usage, see Figure 6.) Not surprisingly, rural miles make up the majority of miles traveled in Maine contrasted with the U.S given the population densities found in the state.

[39] "Natural-Gas Trucks Face Long Haul," Wall Street Journal, May 17, 2011

**FIGURE 11:** U.S. AND MAINE TOTAL VMT PER CAPITA, 2005-2011[40]




[40] Data compiled from Federal Highway Administration, http://www.fhwa.dot.gov/policyinformation/statistics.cfm,and ACS Population Surveys, 2005-2011 and ACS Community Surveys, 1 year Estimates

# 4. STAKEHOLDER INPUT

The legislation that called for this report directed that it should be undertaken with stakeholder input. This section describes how that input was sought and from whom and a high level summary of issues and concerns raised.

## 4.1 OVERVIEW OF STAKEHOLDER INPUT

La Capra Associates developed a list of stakeholders with the input of the Governor's Office of Energy and the Efficiency Maine Trust. An e-mail was sent to the original list of 28 stakeholders alerting them that the report was being undertaken and asking for feedback regarding the best time to hold a workshop to receive comments. Recipients were also asked to forward the e-mail to others they thought would be interested. Nine responded to the survey with affirmative attendance on certain days, while others indicated interest in providing input to the study but would not be able to attend the workshop. In addition to the original list, La Capra Associates continued to identify organizations and individual stakeholders sending them the notices or calling to alert them to the stakeholder meeting.

Based on the feedback from the respondents, a meeting was scheduled for 10:00 a.m. on Wednesday, December 12, 2012 at the State House Office Building in Augusta, Maine. An e-mail was sent to 40 stakeholders, and recipients were again asked to notify others they thought would be interested.

At the stakeholder workshop, La Capra Associates provided a brief overview of the project (including a preliminary baseline consumption outlook) in order to provide starting point for discussion regarding Maine's oil dependence and reduction strategies. Following the presentation, 22 individuals representing more than 20 organizations signed in and nearly all spoke. La Capra Associates offered to meet with organizations individually and followed up with several organizations who indicated they were interested in one-on-one meetings. As a result, a few organizations have sent reports or other information and provided valuable input into the analysis throughout the report as follow-up to the discussions and input provided during the workshop meeting.

## 4.2 STAKEHOLDERS

Stakeholders were chosen to maximize the potential for a wide variety of perspectives and opinions for appropriate oil reduction strategies. The list below covers natural gas and electric local distribution companies, off-pipeline natural gas companies, petroleum delivery companies and wholesalers, environmental groups, consumer and industry groups, energy efficiency advocates, renewable power advocates and developers, and various state agencies.

- Bangor Hydro and Maine Public Service
- Central Maine Power

- Clear Energy
- Office of Economic and Community Development
- Efficiency Maine Trust
- Environment Maine
- Environment Northeast
- Future Metrics
- Global Montello Group
- Greater Portland Council of Governments
- Industrial Energy Consumer Group
- Irving Oil
- Maine Association of Building Efficiency Professionals
- Maine Energy Marketers Association
- Maine Forest Products Council
- Maine Forest Service
- Maine Motor Transportation Association
- Maine Natural Gas
- Maine Pellet Fuels Association
- Maine Pulp & Paper Association
- Maine Renewable Energy Association
- Maine State Chamber of Commerce
- Margaret Chase Smith Policy Center, University of Maine
- Maine Department of Environmental Protection
- Mid-Coast Energy Systems
- National Biodiesel Board
- Natural Resource Council of Maine
- New England Geothermal Professional Assoc
- Northstar Industries
- O'Neil Policy Consulting, Inc
- Oxbow-Sherman Energy
- Summit Utilities
- Transgas

# 4.3 SUMMARY OF COMMENTS

We present a high level summary of the comments received from stakeholders at the meeting and in individual discussions. Stakeholders also provided valuable input regarding the costs and viability of certain strategies and options. These have been incorporated throughout the report.

- At least two companies are positioning themselves to act as "virtual pipelines" delivering natural gas by truck. This has been a successful model in other states where NG pipelines are not yet (or never will be) available. Any user of diesel fuel will likely

benefit from access to natural gas. Barriers include uncertainty around who and how this service will be regulated (want to be declared non-utilities) and siting issues.

- Virtual pipelines provide a good transition to pipeline gas service from local distribution companies. They assist in switching over large customers that can serve as anchor customers to support financing of distribution pipeline expansion.
- Virtual pipelines could serve CNG filling stations, with particular need to focus on trucking needs.
- Railroad infrastructure (for freight) in the state is too risky in terms of reliability and delivery time to fully utilize. Trains would use diesel but would be more efficient.
- Exemption from taxes on diesel fuel may be a source to fund engine conversions on trucks.
- Wood use by the biomass industry does not provide as much value added as used by Maine industries (paper and pulp, wood processing). Concerns about volume of biomass production and whether it is a long-term option to meeting industrial needs (compared to natural gas) and wide scale residential needs. Pellets may be useful for serving most remote customers.
- In the transportation arena, the economics of non-gasoline or hybrids is starting to make sense. Truck idling remains a significant issue despite stations that reduce costs by 75% but are not being used. There is a need for transit planning and public transit. Biodiesel should also be investigated as it is something to put in vehicles over the short term.
- The use of propane should not be discounted for a variety of uses, including transportation, especially since its cost has fallen due to the increase in propane from the shale discoveries in Pennsylvania and elsewhere; it is poised to do well in rural areas and propane vehicles are already here.
- Builders of LNG/CNG storage facilities need to know how these facilities will be regulated and what the codes and standards are in Maine.
- Pellets needs to be part of the discussion regarding reduction of oil dependence. Biomass makes up 66% of Europe's renewable portfolio. Maine has a functioning infrastructure in place to heat homes using pellets. Thus the industry in Maine is poised to handle increased demands. Importantly, the infrastructure was developed with private capital to capture favorable market conditions.
- Money for efficiency should be invested after fuel switching dollars. Today, it frequently happens the other way around.
- There are regulatory issues that could be cleaned up to assist further penetration of biomass technology for residences and businesses (for example, inspections are too slow).
- Maine should adopt a thermal REC carve out. New Hampshire has one. It would reduce oil dependence and would support the biomass industry. A thermal carve out would also support renewable energy at a lower cost than non-thermal RECs (under current market conditions).
- Efficiency Maine Trust recently released its 3-year plan which focuses on demand-side rather than supply (fuel switching). Efficiency programs geared toward oil reduction are

often restricted because of the funding sources. The focus for reducing oil dependence tends to be on stationary uses but transportation is a big part of the picture. Overall, there is currently a tremendous opportunity to couple efficiency with fuel switching.

- Efficiency is the cheapest way to reduce oil dependence. The focus of the oil reduction report should be on transportation, especially transit infrastructure and land use planning.
- Energy Advisors published a report in 2003 that outlined oil reduction options. Transportation is hard to deal with because Maine is a rural state. Pricing policies are driving transportation decision. Heating is the next biggest oil user. The funds for weatherization have dried up. There should be a social benefit charge on oil to fund weatherization.
- State funds help businesses to switch fuels, supplementing the price differential between petroleum products and natural gas.
- Solar should be given consideration. Maine has forty companies in Maine that install solar. It is expensive upfront but the environmental benefits are substantial. There needs to be hard analysis of solar.
- Maine hasn't really had access to gas. The opportunities for large users to expand their use of gas are significant. Capital is a barrier to expanding. The report should consider what the state could do to promote gas pipeline expansions as well as fuel switching. There should be an aggressive policy for growing pipelines. Currently, there is a low interest rate, low gas cost environment—excellent time to grow the pipeline infrastructure.
- Examine possibility of using LIHEAP funds to help with fuel switching. LIHEAP funds tend to support currently relatively expensive fuels, such as electricity and diesel. Fuel switching savings would enable LIHEAP funds to help more users.
- Maine is the 4$^{th}$ most oil dependent state in the nation. The intent of the legislation calling for the oil reduction dependency report was about increasing energy security, fuel options and use of local resources. Wholesale shifting to natural gas (another fossil fuel) was not what the legislature intended. Efficiency is the best option but the funds are disappearing. Transportation considerations should include higher CO2 standards, alternative fuels, public transportation, and commuter reduction policies.
- Price is what drives consumer choices and behavior. Upgrades to furnaces can result in 25% savings. The supply situation has changed since the legislation was passed. Availability and rising price concerns are no longer an issue due to domestic shale and oil discoveries.
- Government should not be making new policies. The focus should be in removing existing barriers that restrict access to capital.
- Utility is offering a solar heat pump pilot program and providing on-bill financing. Users can save 30%. Educational barriers still exist.

Overall, there was the sense that market conditions are quite favorable to switching away from oil and meeting the targets set out in the Act. The 2030 targets in particular were seen as

reachable and one commenter noted that it would not be surprising if that target was already being met for certain sectors (as confirmed by the analysis provided above). There was some disagreement among stakeholders concerning the correct mix of policies and strategies. While some feel that Maine should make a strong push to provide incentives for further availability of natural gas—preferably provided by regulated local distribution companies, but off-pipeline gas can provide a good transition—others comment that natural gas is still a fossil fuel that has negative environmental impacts and energy efficiency (across all modes) should be employed first; others favor biomass options to expansion of natural gas. Finally, there was a common feeling that the Plan should target policies toward the transportation sector because (1) this sector continues to be the largest user of petroleum and a large contributor to greenhouse gas emissions and (2) progress in reducing oil usage in this sector has been slow and continues to be challenging.

# 5. COMPARISON OF COSTS OF VARIOUS OIL REDUCTION STRATEGIES

In this chapter we provide high-level cost estimates of the different strategies and options discussed in Chapter 3. These cost estimates are provided with the goal of comparing options to inform decisions about state policies, legislation, regulations, and other actions. As such, the analysis provided herein is not intended to inform particular resource decisions by individuals, businesses, or institutions, since those analyses would necessarily have to include information about the market conditions at the time, the customer or facility characteristics, and the actual resource decisions to be evaluated.

The methodology of the chapter is to examine the total cost of different strategies by first comparing the delivered cost of different fuel types. A comparison of the current cost of oil (as used by each sector) to fuel cost of alternatives is the first high level comparison that should be made. However, there are also equipment and, in some cases, infrastructure costs to use of alternative fuels that also are relevant. We provide some insight into how ranges for these costs affect the differential between oil costs and alternative fuels.

## 5.1 DELIVERED FUEL COSTS

In the next two sections, we provide a comparison of delivered fuel costs. Given the importance of conversion to natural gas as an oil reduction strategy, we spend some time discussing our estimates of the different ways—existing pipeline, new pipeline, and off-pipeline—natural gas can be delivered. We then compare the costs of natural gas and alternative fuels to existing distillate or diesel costs[41].

### 5.1.1 *NATURAL GAS DELIVERED COSTS*

The table below shows the result of our research and analysis on delivered natural gas costs. We examine delivered fuel costs (including the costs of infrastructure) to four "typical" customers[42]—residential, small C&I, mid-size C&I and smaller natural gas transportation fleet customers, and large industrial customers with truck fleet service or filling stations with large volumes. The first section of the table shows costs to typical customers based on serving existing load (with the existing natural gas distribution system). The next set of values

[41] Though we acknowledge that many industrial users in Maine still use residual oil (Maine DEP data indicate residual oil accounts for over 75% of total petroleum production by industrial users that report their usage to DEP), we do not examine residual oil prices. Maine has stringent sulfur limits that are expected to significantly diminish the use of residual oil by 2018.

[42] These estimates are to be used for general comparison of different fuel types and methods of delivery. They are not intended to be applied to a particular customer's load levels or characteristics.

represents costs to service additional customers by adding additional load (and infrastructure) to the distribution network. Below these two LDC options, we provide the cost of off-pipeline service, which involves delivery of LNG or CNG to customers' facilities and locations via truck. Finally, we present the cost of two options that are currently available to customers—propane delivery and diesel usage.

**TABLE 7:** DELIVERED NATURAL GAS COSTS, 2013 $/MMBTU

| | Residential Sales | Commercial/ Small Industrial Sales | Mid-Size Industrial/ Hospital / Shopping Mall / Smaller NGV Customer | Large Industrial or NGV Fueled Truck Fleet |
|---|---|---|---|---|
| **LDC – Existing Load** | | | | |
| **Supply Commodity** | 6.56 | 6.56 | 4.05 | 4.05 |
| **Interstate Pipeline / Basis Differential** | - | - | 1.75 | 1.75 |
| **NG Distribution** | 6.08 | 4.25 | 3.30 | 2.31 |
| **Total - $/mmBtu** | **$12.64** | **$10.81** | **$9.10** | **$ 8.11** |
| **LDC – Expanded Service Territory** | | | | |
| **Supply Commodity** | 6.56 | 6.56 | 4.05 | 4.05 |
| **Interstate Pipeline / Basis Differential** | - | - | 2.00 | 2.00 |
| **NG Distribution** | 8.50 | 6.00 | 5.00 | 4.00 |
| **Total - $/mmBtu** | **$15.06** | **$12.56** | **$11.05** | **$10.05** |
| | | | | |
| **Delivered CNG/LNG off-pipeline** | n/a | n/a | **$16.00** | **$11.00** |
| | | | | |
| **Delivered Propane[43]** | **$32.12** | **$32.12** | **$26.48** | **$26.78** |
| | | | | |
| **Heating Oil at $3.75/Gallon** | **$27.29** | **$27.29** | **$27.29** | **$27.29** |

Source: Author, EIA, Vermont and Maine Energy Office, Maine LDC, Stakeholder Discussion

Overall, the table shows the clear advantage between LDC-delivered natural gas versus diesel (even at the relatively high level of $3.75/gallon). LDC-delivered gas costs are between one-half and one-third of the price of diesel on a $/mmbtu basis. This differential was frequently cited by

[43] Residential and commercial price reflective as of January 15, 2013 and is equivalent to $2.72/gal taken from: http://maine.gov/energy/fuel_prices/index.shtml; Mid-size industrial and large industrial propane price taken as an average of New England EIA 2013 AEO delivered propane price and estimated delivered prices from propane dealers in VT used as a Maine-proxy

many stakeholders as an important determinant of conversion efforts and one that points to the need to expand the LDC pipeline network. In terms of propane, some stakeholders mentioned that propane could be a viable option to diesel. Though propane prices have fallen recently, they remain elevated when compared to diesel. There is the potential for propane to compete with diesel as additional shale discoveries (and competition from natural gas) puts additional downward pressure on the commodity and possible scale economies of serving larger loads (for heating, for example) reduces delivery costs, but it is unlikely that propane will be cost-effective compared to LDC-delivered natural gas.

Off-pipeline gas costs are also shown in Table 7. This option has been categorized by some stakeholders as a transition to eventual build-out of the distribution network to provide pipeline-provided gas. This option is not available for the smallest customers[44]—except where these customers could be served through a local pipeline system off an off-pipeline served storage facility—but for larger customers, off-pipeline costs are highly competitive with both diesel and propane options. This transition strategy can be done as a partnership with the LDC, where the marketing firm uses its fleet of trucks to compress gas drawn from the utility's distribution system and trucks it on a short-haul basis to customers. Based on our discussions with stakeholders, these strategies work due to relatively short payback periods—the service firm assumes the capital investment risk, which is reflected in the price charged to the customer, and both parties achieve payback within three years, by which time the LDC may be able to obtain franchise rights.

One final comparison to discuss is between the existing load and expanded service territory figures. Expanding service territories adds costs as existing load facilities have depreciation deductions. Hence, though the supply commodity costs are assumed not to change, distribution charges from the utilities will increase. We provide a level-of-magnitude estimate in the table. Actual costs will depend on the specifics of actual expansion plans submitted by utilities. We also adjusted the basis differential that is added onto the supply commodity. As load increases on the interstate pipeline system, we expect pipeline companies to respond by requiring additional basis or delivery payments. Once again, this is an order of magnitude estimate—for, example, actual values may be higher (as much as $3.00 under especially large load increases). Overall, these additional charges and adjustments to account for increased natural gas loads will not materially affect the relative cost advantages of the fuel compared to diesel priced at existing (and anticipated) market prices.

44 There is an economic feasibility threshold of 200,000 to 250,000 gallons/year, depending on whether the marketing firm is conservative or aggressive. All marketers have to achieve necessary scale in order to enter the market offering prices that achieve the one-to-three year pay back range and they need to serve enough customers with a relatively flat process load, like a paper mill or a trucking fleet or refueling station business. This allows the marketing firm to achieve the necessary inventory turnover rate to make it profitable with a given size trucking fleet of its own.

### 5.1.2 *COMPARISON OF DELIVERED FUEL COSTS*

Using the data in Table 7, we provide a comparison of recent data for Maine's home heating by fuel type in Figure 12 below. Heating oil (distillate or diesel) has consistently been the largest source of heating fuel type in Maine. As discussed above, heating oil has declined from being the primary fuel type for home heating from 78.1% in 2005 to 68.7% in 2011, with the fastest declines following the run-up in prices in 2007.

Also shown in the figure are minimum, maximum, and average winter prices for heating fuel in Maine, which have followed an increasing trend since 2005. Clearly, this price increase is not due to any supply/demand dynamic, but is based on world oil prices and oil refinery, wholesaler, and retailer decisions. A noticeable trend is that wood use as heating fuel has nearly doubled during the period of 2005 to 2011. This can be due to an underlying incentive to shift away from heating oil as the majority of Maine residents see their heating bills rise with the price of heating oil. The data also show a move to utility gas, but the rate of growth is more limited due to constraints on submittal and approval of formal expansion plans for approval from the Maine Public Utilities' Commission. Installation of wood or biomass options involves individual decisions and some administrative steps (for inspections, for example) but does not involve extensive regulatory processes with the opportunity for various interveners.

**FIGURE 12:** MAINE HOME HEATING BY FUEL TYPE, 2005-2011[45]

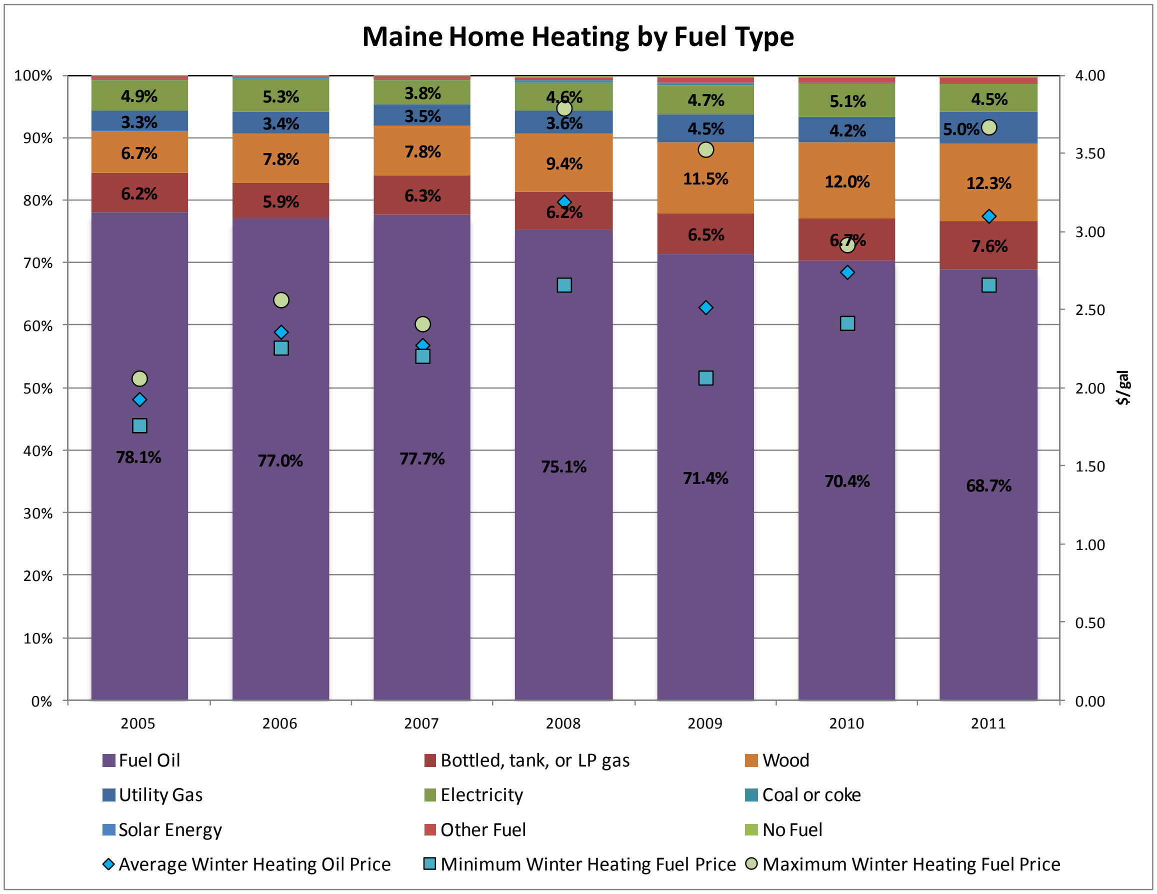
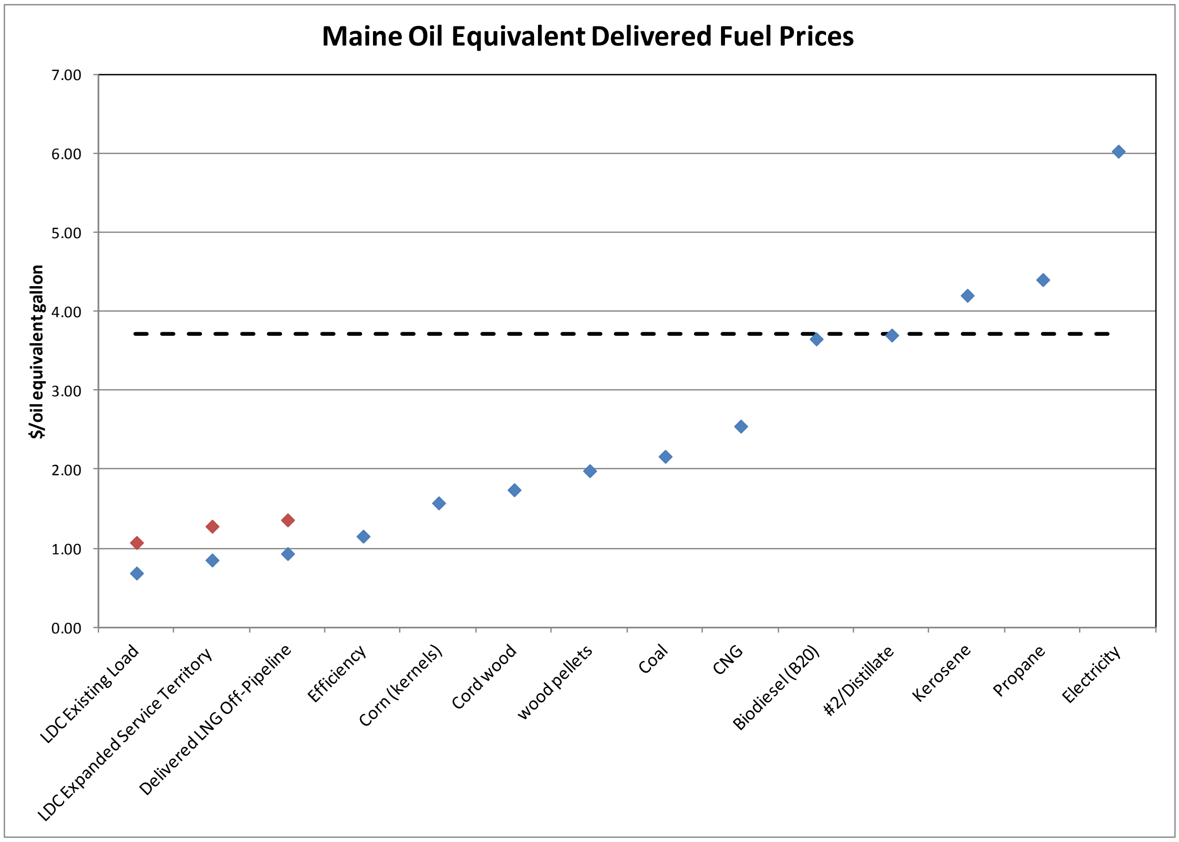



Figure 13 below shows Maine current delivered fuel prices for the different fuel types discussed above. Values are shown on a diesel gallon equivalent ("DGE") basis, and Maine's "current[46]" price for #2 heating oil is shown by the dotted black line. The range in delivered fuel prices for LDC existing load, LDC expanding territory, and delivered LNG off-pipeline is reflective of the different prices for customer classes. As shown in Table 7, delivered fuel prices for a residential customer are higher than prices for industrial customers. Within the industrial customer class, delivered fuel prices will be discounted for large load customers due to scale economies in delivery costs. The data shows that prices for oil (or oil-derived) heating fuels in Maine (including kerosene, biodiesel, and propane) are on the high end of the supply curve. As shown in Figure 12, the majority of Maine residents use oil for home heating which translates to very high heating fuel costs for the majority of Maine residents relative to other states that are able to utilize cheaper fuel sources.

[45] Data compiled from U.S. Census Bureau, American Community Survey (ACS), 2005-2011 and Maine's Governor's Energy Office – Archived Heating Fuel Prices, http://maine.gov/energy/fuel_prices/archives.shtml

[46] "Current" prices are used throughout this analysis and are indicative of current market conditions rather than indicate of prices on particular day.

**FIGURE 13:** MAINE OIL EQUIVALENT FUEL PRICES[47,48,49,50]




This figure shows that on a per unit equivalent basis, natural gas, efficiency and wood fuel alternatives are much cheaper than petroleum fuels. Though propane has traditionally been considered a petroleum fuel—LPG stands for liquid petroleum gas—the strong link between price changes in petroleum fuels and propane appears to have been lessened due to the increased extraction of propane from the natural gas shale plays[51]. Figure 14 shows a historical comparison of residential heating oil and propane prices, but this comparison is also valid for fuel use in other sectors. The data show that in mid-2011, propane prices began to diverge significantly from the pricing trends for heating oil. This is an important trend to monitor and, if

[47] Fuel prices gathered from various sources including:
http://maine.gov/energy/fuel_prices/index.shtml reflected as of January 15, 2013.
http://www.mainepelletheat.com/news/Current-Heating-Oil-Prices
http://www.mainestandardbiofuels.com/collections-fuel/
http://www.afdc.energy.gov/uploads/publication/afpr_oct_12.pdf

[48] Efficiency savings for residential customers cost of $1.16/gal from Efficiency Maine Trust's *Triennial Plan for Fiscal Years 2014-2016*.

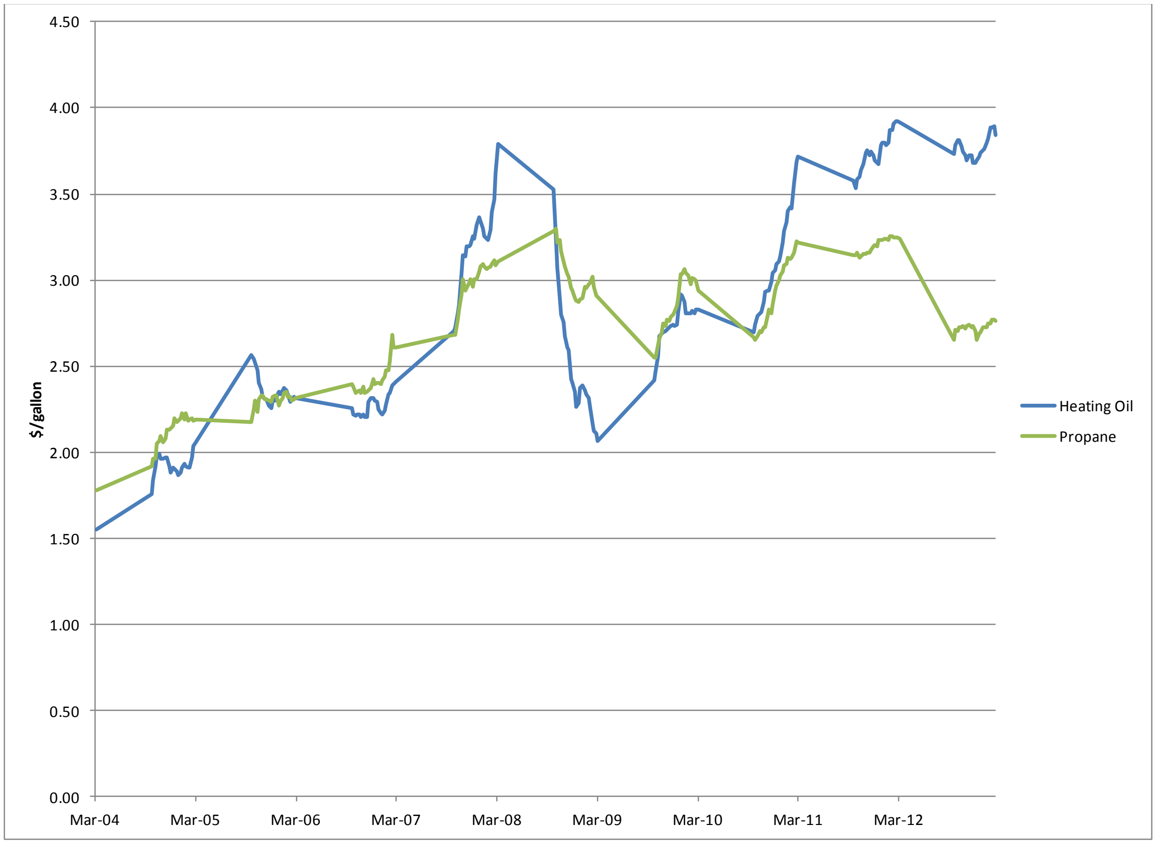
[49] The range in delivered fuel prices for LDC existing load, LDC expanding territory, and delivered LNG off-pipeline is reflective of the different prices for customer classes (residential vs. large industrial).

[50] Electricity price reflects average retail electricity price.

[51] See http://blogs.platts.com/2013/01/09/oil_propane/ as an example

it continues, will increase the viability and use of propane in Maine, especially in areas where natural gas pipelines cannot effectively reach.

**FIGURE 14:** COMPARISON OF MAINE RESIDENTIAL HEATING OIL AND PROPANE PRICES, MARCH 2004-MARCH 2013




While comparing different fuel types on an oil equivalent scale is informative, one must also take into account the efficiency and type of heating appliance in which the fuel is used. We discuss these costs in the next section.

# 5.2 EQUIPMENT AND INFRASTRUCTURE COSTS

In this section, we provide high-level estimates of equipment and infrastructure costs (if applicable) for residential, commercial/industrial, and transportation sectors. As before, these estimates are indicative and assumptions were made regarding investment choices as regards to necessary equipment. The analysis in each section utilizes the price differential between the most used petroleum product (heating oil, gasoline, etc.) in each mode and the particular equipment choice in order to calculate the simple payback period for the equipment.

### 5.2.1 RESIDENTIAL

The payback period of the equipment underlying a whole host of potential residential oil reduction strategies is shown in Table 8. The payback period assumes that the average Maine home uses 97 mmbtu/year[52] and the typical homeowner has a standard oil furnace with an upgraded burner that is 78% efficient. This results in total consumption of 905 gallons at a fuel cost of $3358 per year using #2 heating oil for a typical Maine household. Typical equipment cost ranges are used to determine the payback period range.

**TABLE 8:** PAYBACK PERIOD OF RESIDENTIALOIL REDUCTION STRATEGIES[53] [54]

| | Installed Equipment Cost ($) | Annual Fuel Cost | Payback Period[55] (years) |
|---|---|---|---|
| **Burn Biodiesel in Oil Furnace** | $0 | $3,314 | N/A |
| **Gas Conversion Burner[56]** | $2,500 - $4,500 | $897 | 1.0 – 1.8 |
| **Air Sealing** | $600 | N/A | 2 |
| **New Natural Gas Furnace** | $5,000 - $10,000 | $803 | 2.0 – 3.9 |
| **Wood Stove - Supplemental[57]** | $3,500 - $6,500 | $980 | 5.0 – 9.3 |
| **Solar Hot Water - Supplemental[58]** | $8,300 - $12,900 | $329 | 2.7 – 4.3 |
| **Wood Pellet Furnace[59]** | $10,000 - $22,000 | $1,618 | 5.7 – 12.6 |

52 From Governor's Energy Office Home Heating Calculator. http://www.maine.gov/energy/fuel_prices/heating-calculator.php

53 Assumes biodiesel B20 fuel price at $3.40/gal; propane at $2.72/gal; natural gas for LDC residential existing service delivered price at $12.64/mmbtu and new natural gas furnace efficiency at 95%; efficiency of 90% for more efficient oil furnace and delivered price of #2 heating oil at $3.71/gal; 63% efficiency for wood stove and $210/cord; 70% efficiency for wood pellet furnace and $239/ton; 176% efficiency for efficient air source heat pump and electricity at $0.15/kWh; efficiency of 330% for geothermal heat pump.

54 Prices reflect primary system installation and equipment costs, unless otherwise noted as "supplemental.". These costs do not reflect rebates or tax credits/incentives available. Note that the calculated payback periods reflect current fuel prices and equipment costs and do not reflect future price trends.

55 Payback period indicates how fast (measured in years) the customer's initial cost outlay is recovered as a result of lowered operation costs compared to typical oil furnace operating costs.

56 Assumes that a conversion kit is appropriate for current home heating system.

57 Assumes 50% of heating needs met with wood stove.

58 Only hot water, not a source of home space heating. Assumes electric auxiliary tank system, SEF=2.0, and usage of 12.03 kWh/day. Fuel calculated using: http://energy.gov/energysaver/articles/estimating-cost-and-energy-efficiency-solar-water-heater

59 From correspondence with Maine Pellet Fuel Association, cost estimates reflect level of automation in furnace with estimated fuel costs of $1610/year.

| | Installed Equipment Cost ($) | Annual Fuel Cost | Payback Period[55] (years) |
|---|---|---|---|
| **Insulation (Attic or Basement)[60]** | $2,500 - $8,000 | N/A | 3.3 – 4.4 |
| **Geothermal Heat Pump** | $11,000 - $45,000 | $1,292 | 5.3 – 21.8 |
| **Air Source Electric Heat Pump** | $5,000 - $12,000 | $2,423 | 5.3 – 12.8 |
| **Air Source Heat Pump – Supplemental[61]** | $3,500 - $4,500 | $1,645 | 2.1-2.7 |
| **Solar Photovoltaic - Supplemental[62]** | $18,000 - $30,000 | n/a | 5.4 -8.9 |
| **Propane Conversion Burner** | $2,500 - $4,500 | $3,279 | 21.8 -39.3 |
| **More Efficient Oil Furnace** | $5,000 - $10,000 | $2,910 | 11.2 -22.3 |

Air sealing and insulation options allow customers to make relatively smaller, and scalable, investments to reduce their use of heating oil. They work equally well regardless of what type of heating fuel is used and should last for the life of the building, which means cost savings will extend for many years beyond the payback period. Though customers can pursue efficiency options on their own, the relative cost of energy efficiency options supports pursuit of incentives to increase the rate of speed at which households implement energy efficiency strategies.

Installing a gas conversion burner or installing a new natural gas furnace, on the other hand, both have relatively short pay back times and take advantage of the currently low natural gas price environment. These are not available options if access to natural gas pipelines is not available in the local community.

In terms of renewable options, Burning biodiesel (B20) in one's existing oil furnace does not require any upfront equipment costs but does not provide any significant savings due to the closeness between biodiesel and distillate oil prices. The solar options (especially solar hot water) show relatively modest payback periods, but we do not include any supplemental costs incurred from alternative heating or hot water sources that will be necessary to meet full demand when the solar resource is unavailable or unreliable. Nevertheless, solar options can be effective in displacing existing use of distillate for water heating. The final renewable option, wood, also has relatively short payback periods and takes advantage of a locally sourced and manufactured resource.

The geothermal heat pump has a high range in payback period due to the uncertainty in initial installation costs. Geothermal costs are site specific, thus additional analysis would be necessary to determine a tighter range for these costs.

60 Sufficient to save 25% of heating energy annually.

61 EMT has helped buy/install more than 700 ductless ASHPs as Supplemental Heaters in the past year. Installed price is $3,500-$4,500 for 12,000 Btu. Assumptions are that it displaces 50% of heating load (from oil). Annual fuel costs include electricity charges at 15 cents/kwh and remaining oil use @ $3.69 per gallon.

62 Only includes cost of equipment and installation – will need supplemental backup heating system.

Switching to a more efficient oil furnace provides some benefits, but these are limited since the user will still be subject to the high costs of heating oil. The least effective option (in terms of payback) is installation of propane due to the current high cost of propane (on a diesel gallon equivalent basis).

There are no additional infrastructure requirements outside of the additional pipeline infrastructure costs for natural gas, which are embedded in the numbers above.

### 5.2.2 COMMERCIAL/INDUSTRIAL

The caveats related to the residential price estimates also apply here. Commercial and industrial applications will vary widely, thus it is very difficult to provide an estimate of equipment costs that would apply broadly. Table 9 below is based on work recently done for Connecticut's Comprehensive Energy Strategy[63].

Equipment costs include only those costs related to conversion equipment. Furthermore, we assumed that there are no additional infrastructure requirements outside of the additional pipeline infrastructure costs for natural gas, which are embedded in the numbers above. However, commercial and industrial customers may have to pay upfront connection costs (depending on the circumstance). Any additional costs would subsequently reduce the payback periods above.

**TABLE 9:** PAYBACK PERIOD OF COMMERCIAL AND INDUSTRIAL OIL REDUCTION STRATEGIES

| | Equipment Cost ($) | Fuel Cost | Payback Period (years) |
|---|---|---|---|
| **Commercial Furnace Conversion** | $27,969 | $1,605 | 9.2[64] |
| **Industrial Furnace Conversion** | $52,104 | $11,086 | 2.6[65] |

The disparate payback periods are related to the relationship between the equipment cost and the amount of throughput to capture the price differential between diesel and the alternative fuel (natural gas in this case). The results show that there is a bigger incentive for larger load industrial customers to switch from oil to natural gas furnace in terms of a shorter payback period due to the fact that equipment costs are only twice as high for the larger application while throughput is nearly eight times as high. Hence, larger commercial customers will be able to enjoy shorter payback periods.

63 2012 Connecticut Comprehensive Energy Strategy – Draft for Public Comment, Appendix C: Natural Gas Sector Strategy Analysis. http://www.ct.gov/deep/lib/deep/energy/cep/appendix_c_natural_gas.pdf

64 Assumes usage of 138 mmbtu/year and delivered fuel price of $10.81/mmbtu for LDC Commercial/Small Industrial Existing Load.

65 Assumes usage customer of 933 mmbtu/year and delivered fuel price of $11.05/mmbtu for LDC Mid-Size Industrial Existing Load.

Use of energy efficiency (in terms of weatherization and retrofit of commercial buildings, for example) can also be considered a strategy to reduce oil consumption but we did not specifically examine the cost of such strategies. There is a lack of commercial sector cost data related to measures targeted toward improving oil efficiency. Distributed generation in the form of CHP should also be considered as a viable energy efficiency option.

### 5.2.3 *TRANSPORTATION*

Transportation strategies can affect both passenger and freight transportation and costs are modal-specific. In terms of passenger travel, we first examine use of light duty vehicles (LDVs) powered by alternative fuels.

The payback period of various LDVs of various fuel types is shown in Table 10 below. The vehicles were chosen by lowest manufacturers' suggested retail price (MSRP) for each vehicle fuel type[66]. This selection also resulted in selection of relatively efficient cars—for example, the 2012 Chevrolet Sonic has similar mileage per gallon as some hybrid vehicles.

It is assumed that the typical car owner has an annual driving distance of approximately 12,000 miles (sum of city and highway miles)[67]. We calculate the payback periods based on the fuel costs of an existing, paid in full, light-duty vehicle with an average of 23.5 miles per gallon[68], which reflects the most current data for average fuel efficiency for the existing LDV fleet. The financed cost for each vehicle assumes a 5 year loan period with a 10% interest rate. For simplicity sake, we assume that operation and maintenance (O&M) costs are $0.10/mile for all vehicle fuel types.

[66] Vehicle information found at: http://www.fueleconomy.gov/feg/powerSearch.jsp

[67] Assumption taken from Alternative Fuels Data Center Vehicle Cost Calculator accessible at: http://www.afdc.energy.gov/calc/

[68] U.S. Department of Transportation. Bureau of Transportation Statistics. Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles. http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

**TABLE 10:** PAYBACK PERIOD OF TYPICAL LIGHT-DUTY VEHICLES OF DIFFERENT FUEL TYPES

| Vehicle | Fuel Type | Vehicle MSRP ($) | Fuel Cost Per Mile ($/mile) | Total Cost Per Mile ($/mile) | Payback Period (years) |
|---|---|---|---|---|---|
| 2012 Chevrolet Sonic | Regular Gasoline | $13,865-$17,925 | $0.10 | $0.48 | 5.9 - 7.2 |
| 2012 smart Fortwo coupe | Premium Gasoline | $12,490-$14,690 | $0.10 | $0.45 | 5.1 - 5.9 |
| 2012 Volkswagen Golf Diesel | Diesel | $17,995-$29,440 | $0.11 | $0.58 | 9.8 - 11.8 |
| 2012 Mitsubishi i-MiEV EV | Electricity | $29,125-$31,125 | $0.05 | $0.73 | 5.6 - 12.4 |
| 2012 Ford Focus SFE FWD FFV | E85 | $16,500-$18,300 | $0.10 | $0.53 | 6.3 - 7.3 |
| 2012 Honda Civic CNG | Natural Gas | $26,155-$27,655 | $0.08 | $0.71 | 7.4 - 11.1 |
| 2012 Toyota Prius c Hybrid | Gasoline/Electric | $18,950-$23,230 | $0.07 | $0.55 | 4.9 - 9.3 |
| 2012 Subaru Outback Wagon AWD | Gasoline | $23,295-$31,695 | $0.16 | $0.73 | |

While the electric vehicle has the lowest fuel cost per mile of $0.05/mile, on the order of half the fuel cost per mile of the compact gasoline cars shown in the table, it is more expensive on a total cost per mile basis during the 5 year financing period, since it reflects a higher MSRP price[69]. While the fuel cost of the cars chosen reflect the least expensive late-year models, the average miles per gallon in the U.S. for light duty vehicles is 23.5 mpg which translates to a fuel cost of $0.15/gallon.

Also included in Table 10 is a non-compact AWD vehicle, the Subaru Outback Wagon, which may be more reflective of a typical car[70]. At $0.16/gallon, the fuel costs of the Subaru Outback are three times that of the electricity vehicle, hybrid vehicle, and CNG vehicle. On a total cost per mile basis, the compact gasoline cars have a significant cost advantage. However, the alternative fuel vehicles show that they are very competitive on a fuel cost basis and are also are on par with the total cost per mile when compared to a more typical vehicle.

Another set of possible strategies aimed at reducing oil consumption is use of public transportation. Maine features a number of transit and planning agencies, non-profits, and government entities involved in public transportation. Ideally, we would have collected and analyzed cost data for the various agencies (in terms of measuring $ per passenger mile), but such data were not readily available. As an alternative, Table 11 shows public transportation

69 Reduced financing costs will mitigate the MSRP disadvantage. In addition, we did not consider the different tax credits available to alternative fuel credits, which will further reduce this disadvantage and improve payback periods.

70 Payback periods are not shown for this vehicle, because fuel costs exceed those of the average LDV due to worse gas mileage.

strategy costs per passenger mile on a national basis. These are gross estimates, but they do allow an interesting comparison with the costs provided in the prior table.

**TABLE 11:** PUBLIC TRANSPORTATION STRATEGY COSTS PER PASSENGER MILE[71]

| | Cost per Passenger Mile ($/passenger-mile) |
|---|---|
| **Bus** | 0.896 |
| **Commuter Rail** | 0.427 |
| **Heavy Rail** | 0.388 |
| **Light Rail** | 0.692 |

On a cost per passenger mile basis, both commuter rail and heavy rail are comparable to compact gasoline vehicle costs per mile and cheaper than most of the other alternative vehicles shown in Table 10. Unfortunately, Maine's density does not allow penetration of such strategies. Using the cost per passenger mile measurement to look at the bus public transit strategy, it is slightly more expensive than the costs of vehicle costs. However, this cost is highly dependent on typical passenger trip lengths and may be comparably cost-effective in certain locations. It should be noted that these costs are per passenger mile, thus carpooling would help reduce the public transit cost advantage somewhat. Of course, there are many other reasons beyond cost to pursue public transit including permitting of scale and scope economies in urban areas and promotion of environmental and quality of life impacts that will augment the ability of these strategies to reduce oil consumption (assuming that public transit vehicles are powered by alternative fuels).

A last set of passenger-related strategies are related to reductions in all (including bus) vehicle miles traveled (VMT). Examples of such strategies include carpooling, bike to work programs, pay as you drive insurance (PAYD) and transit-oriented development. As with public transit, these strategies have benefits beyond oil reduction, but these reductions are difficult to quantify.

Commercial vehicles can be used for both passenger and freight transport. Indeed, there has been widespread use of CNG-powered buses in a variety of public transportation settings—public transit, shuttle service, school buses. In addition, CNG is a popular fuel among municipal fleet vehicles. Municipal and other government agencies typically use alternative-fueled vehicles, since conversion costs are relatively low for the popular vehicle types (transit and school buses and refuse trucks) and can result in quick payback periods under certain conditions.[72] Despite these payback periods, there still may be reluctance to convert due to

[71]American Public Transportation Association. 2012 Public Transportation Fact Book. http://www.apta.com/resources/statistics/Documents/FactBook/APTA_2012_Fact%20Book.pdf

[72] See NREL, 2010.

initial up-front costs. Programs, such as the PACE program, are not available for the transportation sector, but may assist more adoption of alternative-fueled vehicles. However, as was discussed in a prior chapter, these vehicles account for a relatively small percentage of overall energy and petroleum usage, thus strategies geared toward additional conversion will not provide the large reductions that are necessary to meet the 2050 target.

Strategies should be geared toward long-haul trucking, which is dominated by diesel fuel. As mentioned in the stakeholder sessions, idling reduction programs and technologies are available but are not always used. Additional education (and possibly continued market pressures) may change this behavior. Freight ton-miles by long-haul trucking are expected to increase, with concomitant increased demand for diesel. This increase serves to offset any reductions (due to more stringent CAFE standards) in petroleum usage by LDVs. Unfortunately, costs to convert existing diesel engines or purchase LNG powered vehicles—LNG is needed to make long-haul options cost-effective—are high, costing double the price of diesel versions[73]. The resulting high payback periods[74] pose a significant barrier to greater penetration of these vehicles, which in turn affects the economics of building additional fueling stations.

Indeed, additional infrastructure costs are the most relevant factor for the success of oil reduction strategies in the transportation sector. In the prior analyses, we examined costs of vehicles powered by alternative fuels, but the adoption and use of these vehicles will be highly dependent on the availability of fueling stations. For electric and hybrid vehicles, charging can generally be done with existing residential equipment. The same is not true for other alternative fuel vehicles, such as CNG, which require additional equipment and may face additional barriers (safety, inspection) to wide scale residential adoption. Moreover, expansion of use of alternative-fuel vehicles for long-haul trucking will require a build-out of fueling station infrastructure. Table 12 shows the number of alternative fueling stations by state in New England.

**TABLE 12:** ALTERNATIVE FUELING STATIONS BY STATE, NEW ENGLAND

| STATE | Biodiesel | CNG | E85 | Electric | HY | LNG | LPG | Total |
|---|---|---|---|---|---|---|---|---|
| **Maine** | 4 | 1 | 1 | 21 | 0 | 0 | 9 | 36 |
| **Connecticut** | 2 | 16 | 1 | 150 | 2 | 1 | 15 | 187 |
| **Massachusetts** | 6 | 20 | 8 | 414 | 1 | 0 | 20 | 469 |
| **New Hampshire** | 3 | 3 | 0 | 42 | 0 | 0 | 11 | 59 |
| **Rhode Island** | 2 | 6 | 0 | 41 | 0 | 0 | 6 | 55 |
| **Vermont** | 1 | 3 | 1 | 28 | 0 | 0 | 4 | 37 |

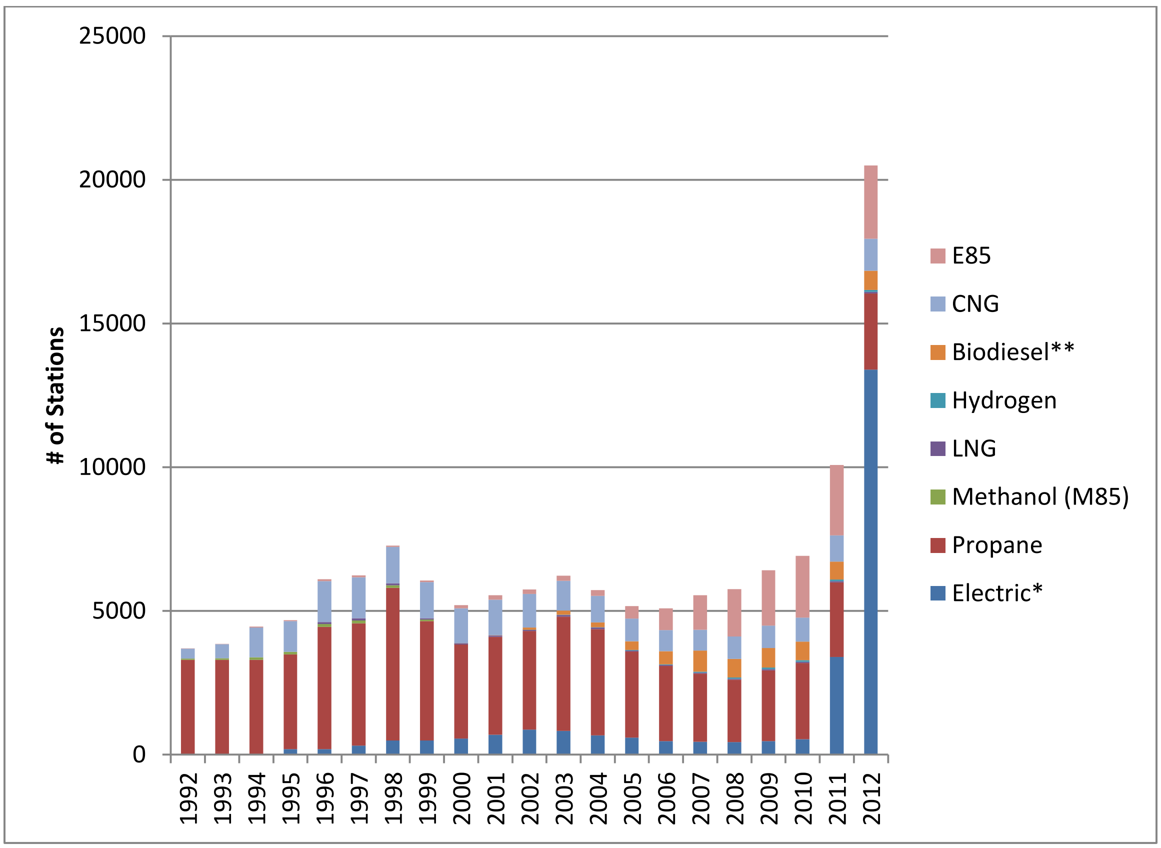
Source: U.S. DOE, Alternative Fuels Data Center

[73] For example, see "Natural-Gas Trucks Face Long Haul," Wall Street Journal, May 17, 2011.

[74] Payback periods are less than the vehicle life, thus these options are cost-effective, but firms almost always require much shorter payback periods to commit to capital expenditures.

The data, which includes both public and private (open to specific vehicles or fleets) stations, shows that only one LNG fueling station exists in the New England region. Clearly, additional stations will be needed to meet the anticipated growth in long-haul traffic. The table shows that Maine has 36 alternative fueling stations, which are the least of all the New England states and possibly due to the large size of the state. Though Maine is well-represented in terms of biodiesel stations, there are relatively few CNG stations. Growth in LNG and CNG has occurred nationally, but is dwarfed by the growth in electric charging stations to accommodate the growth in electric LDVs (see Figure 15).

**FIGURE 15:** ALTERNATIVE FUELING STATIONS, UNITED STATES, 1992-2012




Source: U.S. DOE, Alternative Fuels Data Center

Overall, fueling stations are critical component of any strategy that seeks to reduce petroleum usage in the transportation sector. The cost of stations carries a wide range, depending on the fuel and the speed at which vehicles can be filled or charged. A 2010 study by Pacific Northwest National Laboratory estimated costs for CNG or LNG stations from $10,000 for a home station fed by existing LDC service to $2 million for a large CNG/LNG rapid fill (greater than 15 gasoline gallon equivalents or "GGE" per minute) station, with the smallest CNG station costing $400,000 with a filling capacity of 4 GGEs per minute. Though opportunities exist for development of additional fueling stations by market players without need for government assistance or subsidy based on the current price differential between gasoline/diesel and alternative fuels, the cost of stations need to be covered by a minimum level of sales or throughput. In sum, the speed at

which additional fueling stations (notably for non-electric vehicles) will depend on a number of factors including the continued strength of price differences between diesel and alternative fuels, the fueling station buildup in other states and regions, the adoption of alternative fueled vehicles by large transportation users and fleets, and continued support from state and federal governments.

# APPENDIX – BIBLIOGRAPHY OF STUDIES


1. Governor's Office of Energy Independence and Security. (January 15, 2009). *State of Maine Comprehensive Energy Plan 2008 – 2009.*

2. Strauss, Dr. William. (January 2011). FutureMetrics, LLC. *How to Cure Maine's Addition to Oil: A Roadmap to Avoiding Economic Disaster in Maine and the Other Regional States.*

3. Governor's Office of Energy Independence and Security. (July 2008). *Governor's Pre-Emergency Energy Task Force Final Report.*

4. Maine Department of Environmental Protection. (January 2012). *Report of the Advisory Committee on Reducing Air Emissions Sources' Reliance on Fuel Oil.*

5. Environment Maine Research & Policy Center (Summer 2011). *Getting Off Oil: A 50-State Roadmap for Curbing Our Dependence on Petroleum.*

6. Efficiency Maine Trust. (April 2010). *Triennial Plan of the Efficiency Maine Trust, 2011-2013.*

7. Efficiency Maine Trust (October 2012). *Triennial Plan for Fiscal Years 2014-2016.*

8. Efficiency Maine Trust (December 1, 2011). *2011 Annual Report of the Efficiency Maine Trust.*

9. Efficiency Maine Trust (November 30, 2012). *2012 Annual Report of the Efficiency Maine Trust.*

10. Dickerson, Catherine. Margaret Chase Smith Policy Center, University of Maine. (February 2012). *Energy in Maine.*

11. Governor's Office of Energy Independence and Security. (April 2011). *Residential Geothermal Heating & Cooling Systems in Maine.*

12. Energy Resources Council. (December 2003). *Maine Energy Policy Overview and Opportunities for Improvement.* <http://www.maine.gov/spo/oeis/docs/2003_12_03 EnergyPolicy_OverviewOpportunities.pdf>.

13. Governor's Office of Energy Independence and Security. (April 2011). *Biofuels in Heating Oil.*

14. Maine Department of Environmental Protection. (January 2012). *Fourth Biennial Report on Progress Toward Greenhouse Gas Reduction Goals.*

15. Maine Energy Marketers Association Education Foundation. (September 2010*). Saving Heating Fuel in Maine: Equipment Upgrade Efficiency Study.*

16. Efficiency Maine Trust. (September 2012). *Assessment of Energy-Efficiency and Distributed Generation Baseline and Opportunities.*

17. State of Maine Governor's Energy Office. (2010). *Maine Energy Profile.*

18. U.S. Energy Information Administration, *Table CT4. Residential Sector Energy Consumption Estimates, Selected Years, 1960-2010, Maine*. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_use/res/use_res_ME.html&mstate=Maine>.

19. U.S. Energy Information Administration, *Table CT5. Commercial Sector Energy Consumption Estimates, Selected Years, 1960-2010, Maine*. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_use/com/use_com_ME.html&mstate=Maine>.

20. U.S. Energy Information Administration, *Table CT6. Industrial Sector Energy Consumption Estimates, Selected Years, 1960-2010, Maine*. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_use/ind/use_ind_ME.html&mstate=Maine>.

21. U.S. Energy Information Administration, *Table CT7. Transportation Sector Energy Consumption Estimates, Selected Years, 1960-2010, Maine*. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_use/tra/use_tra_ME.html&mstate=Maine>.

22. Maine's Governor's Energy Office. Archived Heating Fuel Prices, <http://maine.gov/energy/fuel_prices/archives.shtml>.

23. U.S. Energy Information Administration. *2013 Annual Energy Outlook (AEO) Early Release.*< http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2013).pdf>.

24. Cadmus Group, Inc., The. (2012). *Assessment of Energy-Efficiency and Distributed Generation Baseline and Opportunities*. Prepared for Efficiency Maine Trust.

25. NREL (2010). *Business Case for Compressed Natural Gas in Municipal Fleets.*

26. Pacific Northwest National Laboratory (2010). *Issues Affecting Adoption of Natural Gas Fuel in Light and Heavy-Duty Vehicles.* Prepared for U.S. Department of Energy.

27. Summit Blue Consulting & ACEEE. Summary Report of Recently Completed Potential Studies and Extrapolation of Achievable Potential for Maine (2010-2019). < http://www.efficiencymaine.com/docs/board_meeting_documents/Maine%20Potential%20Study%20Results%20%2012%2020%2009.pdf>

28. Efficiency Maine Trust (December 15, 2010*). Heating Fuels Efficiency & Weatherization Fund.*